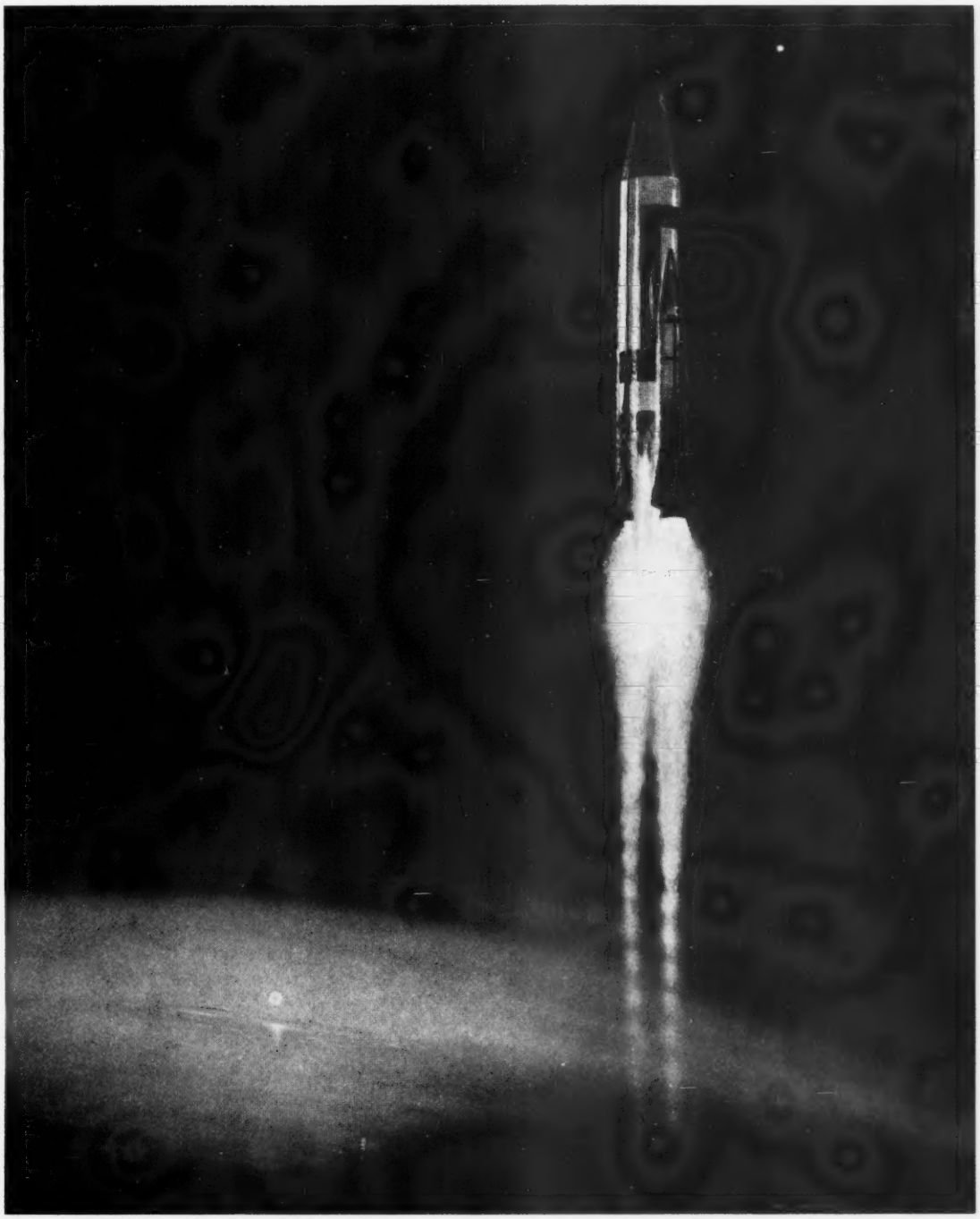
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

MARCH 1958

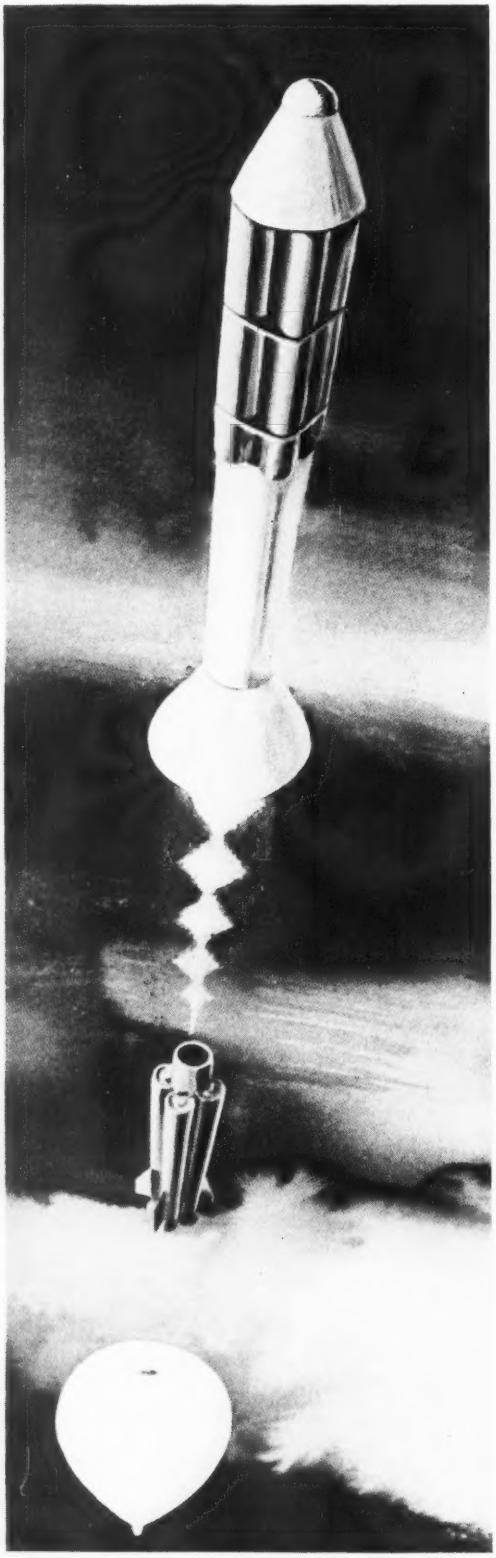


The Lessons of Peenemuende . . . . . Walter R. Dornberger

Flight Space and the Satellites . . . . . John Cobb Cooper

FOUR PAGES ON EXPLORER

FIRST GIANT STEP INTO SPACE



Grand Central Rocket Sets Altitude Record in "Operation Far Side"

The Air Force has confirmed that it recently fired a rocket to a height of more than 4,000 miles above the earth's surface. The 1900-lb. research vehicle with its 3½-lb. instrument package was launched from a balloon-supported platform, 20 miles above Eniwetok atoll in the Pacific.

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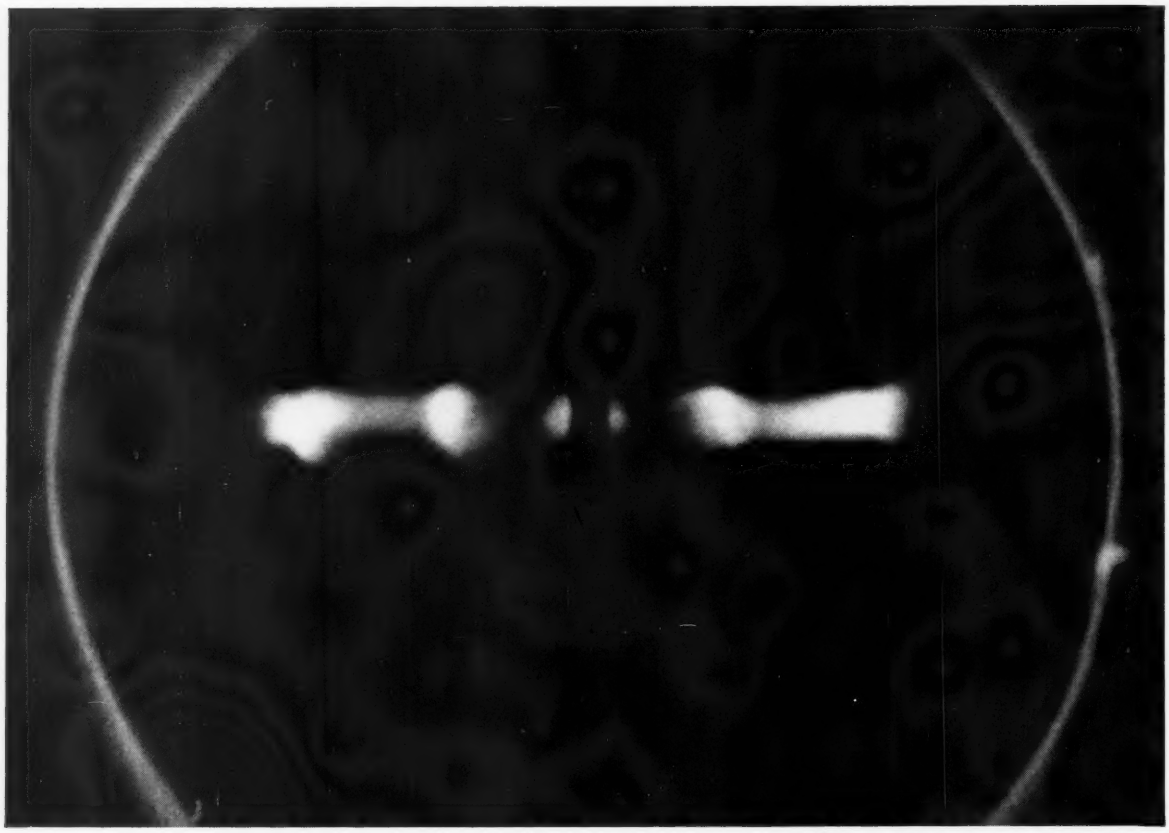

Magnetic fields, acting as a double piston, drive luminous ionized shock waves through transparent tube. One-tenth microsecond exposure in STL's Physical Research Laboratory.

MAGNETOHYDRODYNAMICS and SPACE TECHNOLOGY

Magnetohydrodynamics provides one of the most promising approaches for attaining the velocities and specific impulses that will be required for manned space flight to a planet, landing, and returning.

The critical problem in attaining velocities of hundreds of thousands of miles per hour is the containment of temperatures comparable to those in the interior of stars. Because the temperature of the driving reaction will have to rise as the square of the exhaust velocity, temperatures greater than one million degrees will be encountered in reaction chambers. Magnetohydrodynamics offers a unique solution to the basic problem of containing the reaction without contact with the chamber walls.

Briefly, the physical principles of magnetohydrodynamics are these. Since gas at such temperatures is completely ionized and is an effective conductor of electricity, the introduction of currents in the gas (in this state called a plasma) creates an electromagnetic field. This field makes it possible to control the plasma by applying an external opposing magnetic field which creates a magnetic bottle to contain the charged gas particles. Similarly, a magnetic-field piston can be used to accelerate the particles. Such magnetohydrodynamic reactions are expected to develop exhaust velocities that are an order of magnitude greater than those generated by present chemical rockets.

At Space Technology Laboratories, both analytical and laboratory work are proceeding in the field of magnetohydrodynamics. This work illustrates the advanced research in STL's Physical Research Laboratory, which emphasizes the application of basic physical principles to the requirements of space technology.

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Astronautics

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EDITORIAL

17 The President's Letter . . . . . *George P. Sutton*

FEATURES

18 The Lessons of Peenemuende . . *Walter R. Dornberger*
26 Why Not Dual-Thrust Engines? . . . . *R. S. Newman*
29 Jet Propulsion Looks to the Future . . . . . *Jerry Grey*
32 Flight Space and the Satellites . . . *John Cobb Cooper*
34 Omni-Directional Tracking Systems . . *Walter J. Zable*

U. S. SATELLITE REPORT

22 1958 Alpha—Made in U.S.A.
25 How Microlock Works

ASTRONAUTICS REPORT

36 AFCRC: Test Tube for Tomorrow—Part One
. . . . . *Michael L. Yaffee*

NEWS

21 U. S. IGY Program To Date

DEPARTMENTS

5 At Press Time
8 For the Record
10 Capital Wire
14 Feedback
38 Missile Market
44 In Print
50 ARS News
53 On the Calendar
62 People in the News
66 Patents
72 Government Contracts
76 New Products
88 Index to Advertisers

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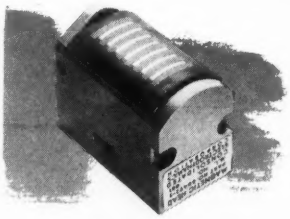
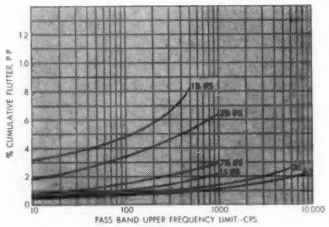
offers

all-metal-surface magnetic heads

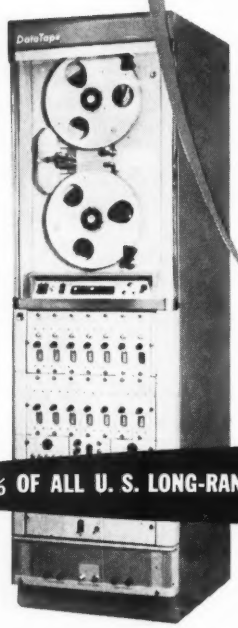


No more drop-outs or loss of high-frequency response because of oxide build-up on heads. All-metal-surface... rather than conventional metal-plastic combinations... promotes a self-cleaning action and minimizes head wear.

lower flutter even at low tape speeds

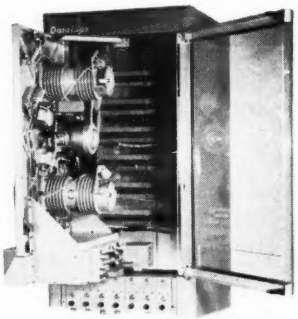


Cumulative flutter at 1⅞ and 3¾ ips is approximately one-half that found in other tape equipment. CEC is first to achieve the low-speed flutter characteristics shown at left. Chart shows flutter recorded at 30 ips and played back at speeds indicated.



complete front access

The 5-752 is the only recorder/reproducer offering complete front access to all incoming and outgoing signal, control, and power interconnections. Access to internal amplifier circuits is through standard connectors on front of unit. All electronics are mounted on drawer slides.



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Simplify your data problems. Get instantaneous playback up to 14 tape tracks with CEC's 5-752 Recorder/Reproducer System with simultaneous recording or reproducing of separate signals on one-inch tape. Seven different types of plug-in amplifiers record and reproduce in Analog, PDM, or FM modes. Contact your nearby CEC field office, or write for Bulletin CEC 1576-X17.

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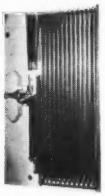
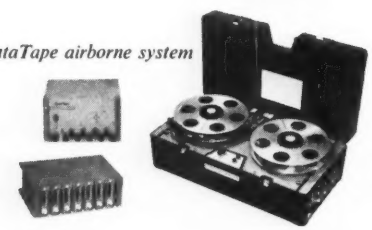


Continuous loop transport

DataTape airborne system



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at press time

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FUELS

• The "Hydyne" fuel used in the first stage of the Jupiter-C which launched the Explorer was a 60-40 mixture of unsymmetrical dimethyl hydrazine and diethylene triamine. It was mixed in these proportions so it would have the same density and vapor pressure as the alcohol it replaced, and gave about 12–15 per cent more thrust. Rocketdyne worked on the fuel last year but it had undergone relatively few tests. In fact, the successful Explorer launching marked the first occasion on which it was used in a large shoot. The oxidant employed was lox.

SATELLITES

• Vanguard failure was traced to a wiring defect in the first-stage control system. After about only one minute of flight, failure in the system caused the engine to deflect to the right and the resultant forces broke the rocket in half, whereupon it was destroyed from the ground.

• Explorer orbit calculations on fifth day: Apogee, 1587 miles; perigee, 219 miles; time, 114.95 minutes. Smithsonian Observatory report on Sputnik II orbit: Apogee diminishing at rate of 3.9 miles per day and time at rate of 0.066 minutes a day.

• With the Navy stymied for the second time in its efforts to launch a small satellite, the Army, successful in its first Explorer firing, was readying a second launch attempt utilizing an instrument package resembling that originally devised for the full-scale Vanguard spherical satellite. JPL handled the job of changing the design of the package so it would fit into the bullet-shaped Jupiter-C satellite shell and also of beefing it up to withstand the heavier G-load and vibration which would be encountered in the more powerful Army vehicle.

EDUCATION

• The graduate-level Space Technology Course being given by the University of California has been a spectacular success, with more than 4500 people attending the course at five different locations. Even more remarkable is the fact that a local TV station is televising the course, the first time a high-level course of this kind has been presented by such a medium.

Meanwhile, other space flight courses are springing up all around the country. The Hayden Planetarium in New York is offering a five-week course for laymen; the Franklin Institute in Philadelphia is offering a lecture course on space travel beginning this month; and a similar course is already under way in Chicago.

NUCLEAR POWER

• AEC gave the public its first look at its propulsion program in Congressional testimony. The commission will seek $10 million more for its Project Rover atomic rocket program and $3 million extra for its Project Pluto atomic ramjet. It is also planning to accelerate ion propulsion research. Revealed for the first time was the previously classified Project Snap, a program envisioning the use of nuclear power in a reconnaissance satellite.

MISSILES

• While Aerojet has a production contract for the Navy's Polaris IRBM, all test vehicles fired to date, including the one fired in the recent successful test, have used solid propellant engines made by Thiokol.

• Great Britain is developing an IRBM whose range will exceed that of the U.S. Thor or Jupiter. The missile is expected to be fired from underground launching sites, minimizing vulnerability to air attacks.

• A total of 11 new ICBM-IRBM launch pads will be built at the AFMTC Cape Canaveral, Fla., launching site.

• AF successfully tested its Mace surface-to-surface missile in a 650-mile flight. The Mace, an advanced version of the Matador, has a new completely self-contained guidance system which is impervious to jamming. Turbojet-powered, it is 44 ft long, 54 in. in diam and has a 23-ft wing span.

• Navy successfully tested its new anti-submarine weapon, the Rat (Rocket-Assisted Torpedo). The missile is propelled skyward by means of a rocket booster. Booster and airframe then drop off, releasing torpedo, which drops to sea by parachute. It is fired from launcher which can be built onto destroyer's 5-in. gun mounts.

• An Atlas ICBM destroyed itself after the powered phase of its flight in a limited-range test firing at Cape Canaveral, Fla. Despite this setback, Atlas is expected to be in production by the end of next year.

• The Pentagon revealed progress on future missile projects in a special press briefing. Anti-satellite weapons, 3000-mile anti-missile radar defenses and three new missiles—the Navy's air-to-surface Corvus and the AF's air-to-surface Bull Goose and ground-to-air Green Quail—were discussed at the briefing.

SPACE AGENCY

• Mounting controversy over civilian-versus-military control of an over-all space agency will be resolved by a special bipartisan Senatorial committee, with an assist from James R. Killian Jr., science adviser to the President. The committee will report to the Senate by June 1 on whether the nation's space program should be left in the Pentagon or turned over to a civilian agency. Dr. Killian has been directed to report on what type of agency should be set up and where it should fit in the over-all government structure. Congressional leaders expect a law on space research and development to be passed this year.

Meanwhile, a Senate-House conference committee skirted a final decision on the issue by writing into an AF construction bill compromise language allowing the Secretary of Defense to go ahead for a year with R&D work on advanced weapons systems and satellites, but neither authorizing nor prohibiting establishment of the Advanced Research Projects Agency within DOD.

• Roy W. Johnson, a vice-president of General Electric Co., was named chief of ARPA. He will take over the new post April 1. A technical director for the agency is expected to be named within the next few weeks.

• Defense Secretary McElroy announced that the AF will probably get the job of operating space ships and other manned space vehicles. He also indicated that the Pentagon would prefer collaboration with NACA on space flight, rather than with a new civilian agency patterned after the AEC.

ROUNDUP

• Lockheed has received an AF go-ahead for its Pied Piper reconnaissance satellite project. Initial contract was for components . . . With authorization to work on 500-mile solid-fuel Pershing (Redstone's successor) and successful Explorer launching under its belt, Army is regarded as good bet to move back into IRBM field from which it was banned by Wilson directive . . . Congressman Ralph Yarborough (D., Tex.) has introduced a bill calling for initiation of an NSF-directed program aimed at providing maximum use of data obtained from satellites and other space vehicles, with primary emphasis on peaceful uses of such information for communications, weather modification, etc.

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Hydraulically powered air compressors, accumulators and various other components of an airborne hydraulic system are performance-proven with this Sun-designed High Pressure Pneumatic and Hydraulic Test Stand, Model LS-244.

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GENERAL SPECIFICATIONS

Model No.	LS-224
Nomenclature	High Pressure Pneumatic and Hydraulic Test Stand
Purpose	Hydraulic Components Tester
Dynamic Hydraulic System	Remote supply, delivers 5 gpm at 3000 psi
Static Hydraulic System	Remote supply, delivers 1 gpm at 100 psi boosted to 20,000 psi by air-operated boost pump
Pneumatic System	100 psi
Controls and Instrumentation	Circuit controls, pressure gages and flowmeters. Illuminated instrument and Control panel recessed and angled for easy viewing and operation

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for the record

The month's news in review

Jan. **2**—Navy proposes that first U. S. nuclear-powered aircraft be a seaplane.

Jan. **3**—AF forms first two squadrons to be armed with Thor and Jupiter IRBM's.

—University of Michigan plans to build 100-ft-high steerable radio telescope.

Jan. **4**—Static firing of Atlas is successful.

—Lieut. Gen. James M. Gavin, Army R&D Chief, announces his retirement.

—Talks begin on placement of U. S. missile bases in France.

Jan. **6**—Rockefeller Report recommends accelerated missile production, research program and retaliatory submarine system.

Jan. **7**—President asks additional $1.3 billion for missiles and air defense. Of this, $1.26 billion would be new funds.

—AF plan for atomic plane gets okay from Joint Atomic Energy Committee.

Jan. **8**—Defense Secretary McElroy says administration's request for supplementary funds will permit prompt production of missile subs.

Jan. **9**—President's State-of-Union Message calls for more long-range missiles and missile-armed submarines.

Jan. **10**—Maj. Gen. Bernard A. Schriever assails DOD's plan for unified agency for space weapons research.

—DOD orders Army to develop solid-fuel ballistic missile to replace Redstone.

—AF successfully fires another Atlas.

Jan. **12**—President calls on Soviet to agree to use outer space only for peaceful purposes.

—NACA names H. Guyford Stever of MIT to head special group on space technology.

Jan. **13**—President's budget message asks Congress for $2.5 billion more than in 1958 for missiles and outer space weapons.

Jan. **14**—Redstone and Bomarc fired successfully.

—AF plans to launch a military reconnaissance satellite with recoverable capsule by spring of 1959.

—Lieut. Gen. Arthur G. Trudeau replaces Gen. Gavin as Army R&D Chief.

Jan. **15**—House votes funds for newly developed ballistic-missile warning system and for third ICBM launching base.

—Senate Preparedness Committee hears missile manufacturers doubt that a reliable ICBM would be ready for use before end of 1959.

Jan. **17**—Navy successfully fires Polaris test vehicle.

—First Jupiter squadron trains at ABMA.

Jan. **18**—DOD assumes responsibility for anti-missile missile program until new Advance Research Projects Agency is organized.

—Snark missile squadron is formed at Patrick AFB, Fla.

Jan. **20**—Polaris progress "amazing," Navy tells Congress, revealing plans to seek early funds for nine nuclear-powered subs to carry the missiles.

—Soviet news agency Tass reports first earth satellite died Jan. 4.

Jan. **21**—House Appropriations Committee gives President full $1.2 billion requested for missile speed-up, and an extra $40 million for new Pershing and other short-range Army missiles.

—AF Missile Chief says U. S. has technical ability to send a man into space "quite soon."

Jan. **22**—NRL announces Vanguard will contain yeast to determine space travel effects on simple life forms.

—Lockheed is building wind tunnel to test Polaris.

—Maj. Gen. Robert J. Wood, Deputy Chief of Army R&D, discloses "excellent progress" on Plato and Zeus anti-missile missiles.

Jan. **25**—Moscow radio says Krushchev agrees to discussion of ICBM ban as part of general disarmament agreement.

Jan. **26**—Vanguard firing is called off.

Jan. **27**—Army's Jupiter-C gets priority to put earth satellite into orbit.

—DOD decision on first atomic-powered airplane put off to future date.

Jan. **28**—AF announces successful test firing of another Thor IRBM.

—Army says it will have operational Nike-Hercules in New York, Washington-Baltimore, Chicago and Philadelphia areas next June.

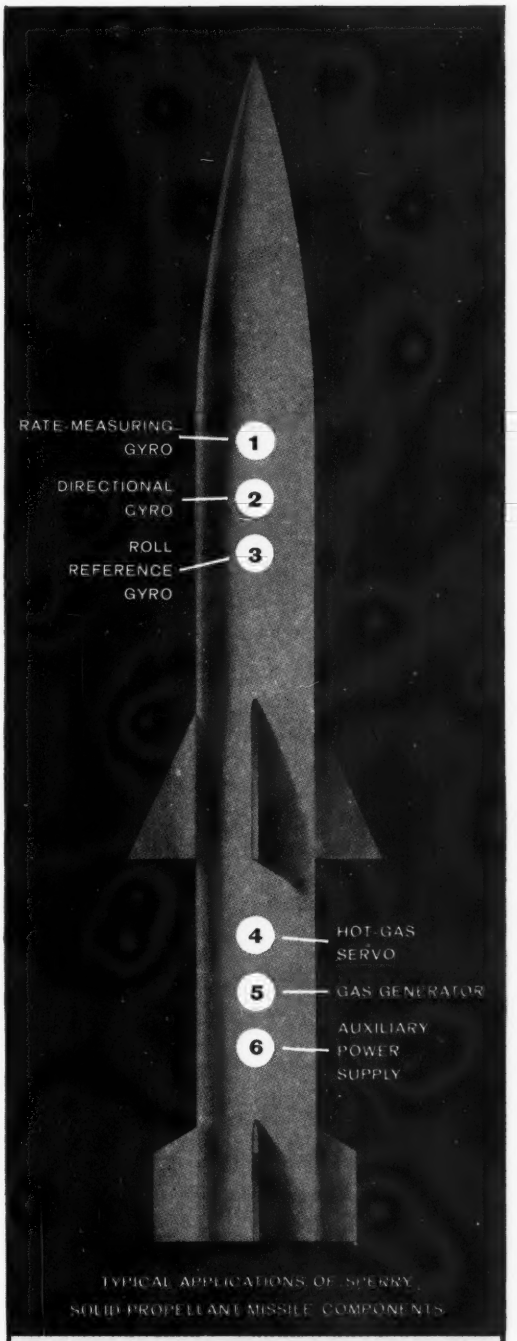
Jan. **29**—AF restudy of previous day's Thor firing finds missile deviated from course.

—U. S. announces plans to set up missile test range on Pacific Coast.

Jan. **30**—Army chiefs warn Congress that Russia may have operational ICBM as early as next July.

—Capt. Iven C. Kincheloe Jr. reveals that X-15 program is scheduled to begin in spring of 1959.

Jan. **31**—Army's Jupiter-C successfully puts U. S. earth satellite into orbit.



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capital wire

News highlights from Washington

CONGRESS

• Congress has been displaying a healthy awareness of the dawning Space Age. Early in the session Rep. Kenneth Keating (R., N.Y.) offered a bill to establish a Joint Congressional Committee on Outer Space, modeled on the highly successful Joint Atomic Energy Committee. Keating proposed that the committee have jurisdiction over research and development, production, security standards, safety and international aspects of space problems.

Rep. Thomas J. Lane (D., Mass.), and Rep. Merwin Coad (D., Iowa) offered bills that would establish a commission to foster astronautical development.

BUDGET

• Army success in orbiting "Explorer" will only partially relieve pressure on the administration. Knowledgeable Congressmen understand Jupiter-C vehicle is a fairly unsophisticated jury rig, effective for its job, but no substitute for more advanced space vehicles. Moreover, revelations in testimony before Senate Preparedness Subcommittee have made a profound impression on Capitol Hill.

It's still likely, therefore, that Congress won't be satisfied with what it considers a low-thrust military budget. Appropriation committees may try to up spending on missiles, space research and production of bomber aircraft. Defense Secretary McElroy has promised to ask for more money if he needs it, which gives the Administration a chance to regain the initiative if it wishes.

Hearings on budget details should reveal that, despite increase in funds for research, expansion of the effort won't be very great. Problem is that as projects mature they begin to cost more, so new money goes largely for sustaining the present effort —and not enough new research is undertaken. Congress is in a mood to do something about that.

SPACE AGENCIES

• NACA will probably follow up its strong bid for control of nonmilitary space research with an effort to obtain more funds from Congress. While specific estimates are not ready, off-the-cuff guess is that about $500 million would give NACA what it wants—additional facilities and a sharp increase in emphasis on space problems.

AF and the aircraft industry support NACA's position, but whether a real space effort—such as ARS proposed—will result, remains doubtful.

• Defense Secretary McElroy's difficulty in finding someone to head the proposed Advanced Research Projects Agency (ARPA), and the consequent delay in setting up the new agency, have weakened the concept even before it is a reality. Had McElroy been able to get the machinery functioning promptly, dissident forces, even in Congress, wouldn't have had much chance. Now ARPA, when it arrives, is likely to be seriously hobbled by the terms under which it gets its money.

• Sen. Clinton P. Anderson has meanwhile been trying to put the Atomic Energy Commission in the space business, and there are some who suspect AEC is not unwilling. Anderson was instrumental in removing specific mention of ARPA (McElroy's proposed Advance Research Projects Agency in the Pentagon) from the appropriations bill funding it.

The Arizona lawmaker is convinced nuclear propulsion is the real answer to the conquest of space, which is why he mentions AEC. But his principal aim is to put space matters under civilian control, and if the administration wanted to create a new agency, he would probably support it.

PENTAGON

• Top missilemen in Pentagon are pleading for an "interim space program" that can get started promptly without waiting for basic policy and administrative decisions, painfully slow in coming.

Responding to McElroy's request, the services have come up with a number of space proposals. These range from various types of reconnaissance satellites to projects involving manned space flight, reconnaissance stations on the moon, and flights to other planets. Talk is also mounting of the need for an anti-satellite vehicle of some kind.

MISSILES

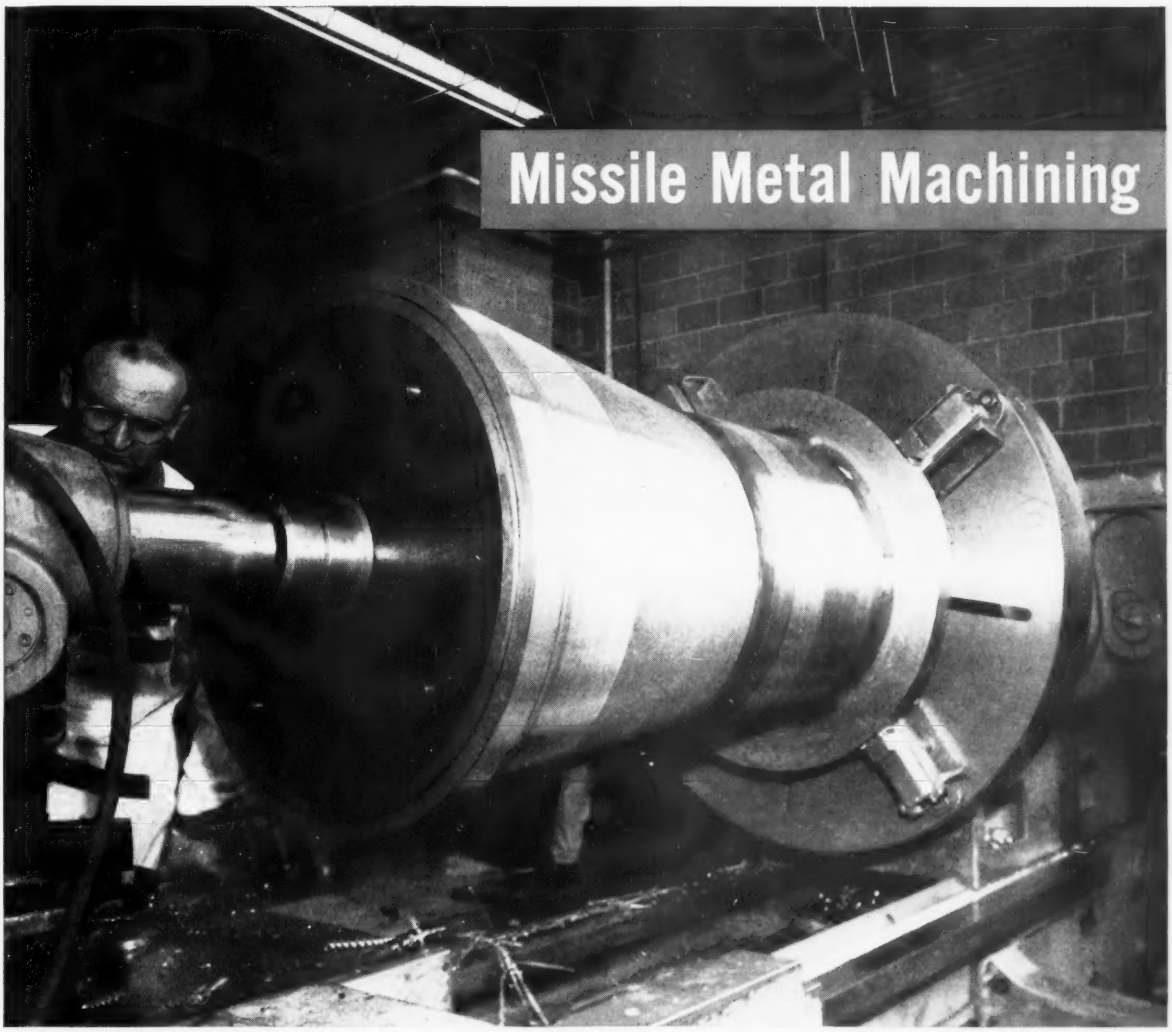
• It's not generally realized, but biggest increase in missile program spending will involve bases, not weapons. Only three ICBM bases have been budgeted so far (two in fiscal '58, one in fiscal '59), and quite a few more will be needed—at about $100 million apiece. AF insiders predict that, if bases and ground-handling equipment are to keep pace with weapon production, the Administration will have to ask Congress for another supplemental appropriation before this session ends.

• The big ballistic missile programs—Thor, Jupiter, Polaris, Atlas and Titan—will account for almost half of all missile procurement in fiscal 1959.

• Possibility of underground firing tubes at ICBM bases is getting serious AF consideration. In addition to problem posed by exhaust flames and gas, missile must be protected from damage as it emerges from tube. Perfection of a method would increase missile base costs, and probability is that only some of the firing sites at a base would be of the underground type.

NUCLEAR PROPULSION

• Tests of a nuclear rocket propulsion system may begin late this year at the AEC's Nevada proving grounds. Officials are encouraged enough to think more could be spent efficiently right now, but the "Project Rover" nuclear rocket is still a long time away.



Big Nozzles for Big Rockets

Behind the tailstock you see a Diversey craftsman ready to take a cut that will trace the bottom flange and taper of the O.D. of the nozzle. As nozzles go, this one is big . . . real big. It is the nozzle for one of the large rocket motors.

At Diversey you have the LARGEST FACILITIES exclusively devoted to your missile metal machining problems. You work with fast, precise and progressive technical people who know what works and what won't. Bring your big missile problems to Diversey.

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FRANKLIN PARK, ILLINOIS • *A Suburb of Chicago*

FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

THIRD OF A SERIES

Why you get reliability in Cannon Plugs

There's more to reliability than meets the eye ... a thousand inspectors cannot put reliability into an item that is inherently weak in engineering or production design ... reliability in a component is obtained only when the manufacturer is aware of the challenges involved in attaining reliability ... and is geared and operates to meet those challenges head on!

In *your* interest ... we'd like to demonstrate that we at Cannon *are* well aware of the tremendous importance of Reliability and the challenges and problems it presents.

You ... as a purchaser of Cannon Plugs ... have a stake in the way we meet these problems. It is to your interest to know why you can expect reliability of a high order in every Cannon Plug you purchase. To you it means confidence, peace-of-mind, pride in your product, because it will perform even better than specified.

Some people say 100% inspection is the answer to the reliability challenge.

Some say experience is the answer.

Others stress that reliability comes from people, equipment, quality control, and statistical techniques.

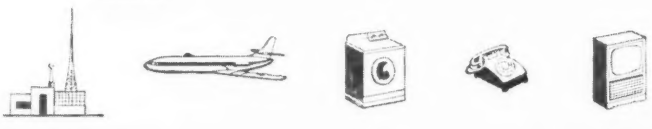
They may be correct, but in our humble opinion, the building of reliability into a product requires a much broader viewpoint, a wider understanding of all the facets of the problem. We'd like to submit these ...

- ***"Awareness" of existence of the reliability problem***
- ***"Integrity of intent" on the part of the manufacturer***
- ***Financial ability to take the necessary steps***
- ***Management ability***
- ***Manufacturing equipment and control***
- ***Plant capacity and flexibility***
- ***Design and engineering know-how***
- ***Employee selection and training***
- ***Long-range master planning***
- ***In-plant industrial and production engineering***
- ***Research, testing, development laboratory activities***
- ***Continuous reliability and assurance testing during the manufacturing operation and required corrective action***
- ***Collection and analysis of failure data, and corrective action***
- ***Recognition of end use requirements and environmental conditions***
- ***Complete testing of prototype to end-use requirements***
- ***All of these facets in depth***

Specifically ... how do we here at Cannon meet reliability problems?

Fortunately, we feel, we are aware of the problem. The atmosphere here, since our inception in 1915, has included a design and manufacturing philosophy embracing the highest quality and reliability in each Cannon Plug for the specific application for which it is to be used. *If we cannot design to that principle, we do not make it!* Even on connectors designed to customer or MIL-spec we constantly strive to give even more ... to increase the safety factor ... to give that "something extra" according to our own high "Cannon Standards."

Fortunately, too, we have the financial stability and resources to indulge in this relatively high-minded philosophy of business. In all of our eight plants, located in seven countries, we have management acumen of the highest calibre.



We have a *Master Planning Group*... looking to the future... investigating the newest in technological improvements, providing interplant project coordination for maximum flexibility to meet the challenges of our ever-changing future.

We have an *Industrial Engineering Group*... experts who call out the materials, methods, and processes to be used in the manufacturing cycle... experts who collect, analyze, and institute corrective action in accordance with field failure data.

We have *Sales Engineers* (fully qualified technical men who contact our customers).

In the checking of failure data we have two main areas — one is in the research and testing phases and one is in the production phase. In the research and testing phases we have *Design Engineers* (specialists in past and present design methods who analyze failure data caused by design inadequacies and initiate corrective action).

Then, there is our *Development Engineering and Model Shop Group*, specializing in the development of prototypes.

In the production phase we have *Product Engineers* (specialists in particular types of connectors).

We have an outstanding *Quality Control Group*... well qualified to administer the high requirements of "Cannon Standards"... staffed by well trained inspectors and analysts equipped with the most modern equipment.

We have a *Quality Engineering Group*. They handle the technical aspects of sampling plans, preparation of inspection and test procedure to realize the customer's desired quality level and the over-all quality level of the entire Cannon manufacturing operation.

Our *Materials and Processes Laboratory Group* works in both the research and production phases. This is the group that checks performance of new designs, constantly investigates new materials and processes, and (over and above normal manufacturing supervision and quality control operations) runs continuous reliability and assurance tests on the manufacturing cycle.

Finally, we regard our operation as a large, well-organized job shop, even though we have many of our more than 20,000 different types of plugs in stock... each plug, in its past history, has gone through the routine of design, development and testing.

Let's see how this works in detail. Let's assume you want Item R, but "with these modifications."

The first man you see is our Sales Engineer. You give him your requirements and specifications. You call out the different operating conditions.

Our Sales Engineer presents your requirements to one of our highly specialized Product Engineers. This expert re-analyzes your problem, your application. He wants to know if it matches up with Cannon's production facilities, Cannon abilities, and Cannon's consistent high standard of quality. Then he re-draws your specifications... adding his know-how to make the product even better than you thought possible. He can do this, because he and his associates are engaged in daily manufacture of over 50,000 similar items. In many cases, a little "plus" can be added, thus increasing your factor of safety. At the same time he works with a highly specialized Design Engineer to compile test specifications required to assure the high reliability desired in the connectors you need. He then returns these papers through our Sales Engineer to you for review and O.K.

Prototypes are made by our Development Engineering and Model Shop Group and sent to the Cannon Materials and Processes Laboratory for testing. In these Laboratories, your prototype is tested to see that all specifications are met... physical, operating, environmental. Test reports are made up, and presented to you for review and approval. Not until all these steps have been taken is your order placed in production.

With the order in production, normal quality control systems go into effect. Materials are processed through receiving inspection. Process, re-work and final inspection barriers are set up. In addition to standard Military and Cannon manuals of quality control procedures, specific jobs... such as yours ... may require additional special inspection or testing. If so, these requirements are established throughout the process, and where necessary, coordinated with you. Our failure data collection and analysis in this field has given us intimate knowledge of the critical points at which such control should be used. Recognized statistical control procedures are used both in process and at the inspection points.

However, independently of the normal quality control operations, our Materials and Processes Laboratory works with Quality Engineering and continuously, on a planned basis, runs monitoring tests on all materials, solutions and processes throughout the plant.

In addition, as general policy, samplings of the complete manufactured lots come back to the Materials and Processes Laboratory for complete quality assurance testing and verification against the original specs.

Thus, here we find Reliability and Assurance Control superimposed on Quality Control. The Materials and Processes Laboratory personnel *can and do* step in at any point for their verification-checks.

Constant research is carried on, too, into possibilities of new materials, new components, new finishes, new processes, new equipment, new methods, new chemicals and packaging... above and beyond customer specifications.

*

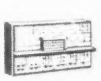
We are *aware* of your problem of "Reliability" and are working to solve it. At Cannon "Reliability" is designed and built into each plug.

Whenever *you* have an electric connector reliability problem... in design, engineering, production, prototype or testing phases... we would appreciate the opportunity of discussing the subject with you.

Cordially,

Robert J. Cannon *President*

CANNON ELECTRIC COMPANY
3208 Humboldt Street, Los Angeles 31, California



Please Refer to Dept. 504

CANNON PLUGS

Eight plants around the seven seas!

feedback

Kudos for Summerfield

Dear Sirs:

I would like to commend ASTRONAUTICS for publishing and Prof. Martin Summerfield for writing the excellent articles entitled "Problems of Launching an Earth Satellite." This two-part report presents a very readable account of what is required in launching a satellite. It served as an introduction to many laymen, and brought perspective and clarity to engineers and scientists in associated fields.

The articles have helped increase the interest of engineers and lay people alike in ASTRONAUTICS.

Keep up the good work. You have done us and the Society a service.

ROBERT A. GROSS
Chief Research Engineer
Fairchild Engine Div.
Deer Park, Long Island, N. Y.

Dear Sirs:

Since the first issue of ASTRONAUTICS, I've wanted to write to congratulate you on the excellence of the magazine, and the December issue, with the excellent articles on "Problems of Launching an Earth Satellite" by Martin Summerfield and "Sputnik and Vanguard: A Comparison" by H. H. Koelle, plus all the usual features, which have prompted me to take the time to drop you this line.

I think the magazine is doing a fine job for the ARS membership in presenting, in a most attractive form, the kind of information we need to keep up with our very rapidly moving field. I simply don't have time to read all the literature available and, by confining myself to ASTRONAUTICS, find that I am able to keep quite well informed.

Please keep up the good work.

CHARLES W. WILLIAMS
Branch Manager
Fabrication & Assembly
Chrysler Corp. Missile Operations
Detroit, Mich.

On an ARS Rocket

Sir:

Received my copy of ASTRONAUTICS today, and am writing, per your request, as to Mr. Upton's proposal (January ASTRONAUTICS, page 14) to launch a Society-sponsored rocket. I am for it! Though I do not rank in the high-income bracket, I'm sure I could subscribe to the amount he proposed, and perhaps a bit more, if needed.

My job, family and certain circumstances keep me from being as active as I would like to be within the formation of our Society, and I'm sure there are more like myself. But this venture would make me feel a lot more like I was part of a team.

PAUL E. ROSENBERGER
Elgin, Ill.

Dear Sir:

I am writing this letter in reference to Mr. Richard Upton's proposal in the January issue of ASTRONAUTICS.

Mr. Upton's suggested "moon orbiter" project has prompted me to speak up about something which, I'm sure, must have made many an ARS member wonder from time to time—namely, why the ARS doesn't have an organized "experimental and development program" in the field, so to speak.

Every member of our Society has expressed an interest in the field of rocketry, and I for one see no reason why the ARS cannot organize an *active* program featuring the use of various rocket vehicles. Some may recall that ARS did have an experimental program in the '30's. However, now that we have begun the conquest of space, ARS is caught with its nose cones down!

Certainly ARS has the manpower, brain-power and can have the financial-power, through the means of shares and contributions, as Mr. Upton suggested.

I do not agree, however, with Mr. Upton's proposed moon orbiter. Not that it is not a good idea—indeed, it is. But I believe such a project is a little too ambitious at this point. I would suggest a program including the logical steps which would lead up to, and beyond, such an orbiter.

Again, this "step program" would meet a great deal of opposition from the government. I truly believe, however, that with capable leaders and the support of every ARS member, the program could be carried out successfully. . .

It's high time we got our nose cones out from behind the Russian exhaust nozzles and left them wallowing in our exhaust gases.

RUDOLPH HEMPE
Roger Williams Planetarium
Park Museum
Providence 5, R. I.

Gentlemen:

In response to Mr. Richard E. Upton's suggestion, may I add a hearty "I second the motion."

Richard A. Gilbert
ARS Central Colorado Section

Replies to Engstrom

Gentlemen:

In the January issue (page 78) you carried an account by the Swedish engineer, Robert Engström. He feels that I "have not adequately accounted for the laws of celestial mechanics" and that H-bomb explosions on the moon's surface might lead to huge tides on the earth.

His thoughts are interesting but his physics incorrect. It is quite irrelevant to compare the *energies* of an explosion and of tidal friction.

The correct approach is to consider first how the explosion affects the moon's *linear* momentum, which is 7.35×10^{25}g $\times$ 1.02 $\times$ 10^5cm/s ($= 7.5 \times 10^{30}$g — cm/s). The momentum imparted to the moon by the explosion, however, is only $\sim 10^{11}$g — cm/s, an entirely negligible amount. The important contribution is from the ejected material. Assuming that *all* of it has escape velocity (certainly an extreme assumption), we need only compare the *volume* of ejected material, about 10^{11} cm^3, to the lunar volume 2.2×10^{25} cm^3, a ratio of $\sim 10^{-11}$.

Using this same argument, we can show that the impact of a moderate meteorite would be much more important. For example, the production of one of the tiniest of lunar craters, Piazzi Smyth, would have affected the moon's momentum more than 100 times.

This discussion above has nothing to do with how fast a Foucault pendulum turns.

S. F. Singer
Associate Professor
University of Maryland
College Park, Maryland

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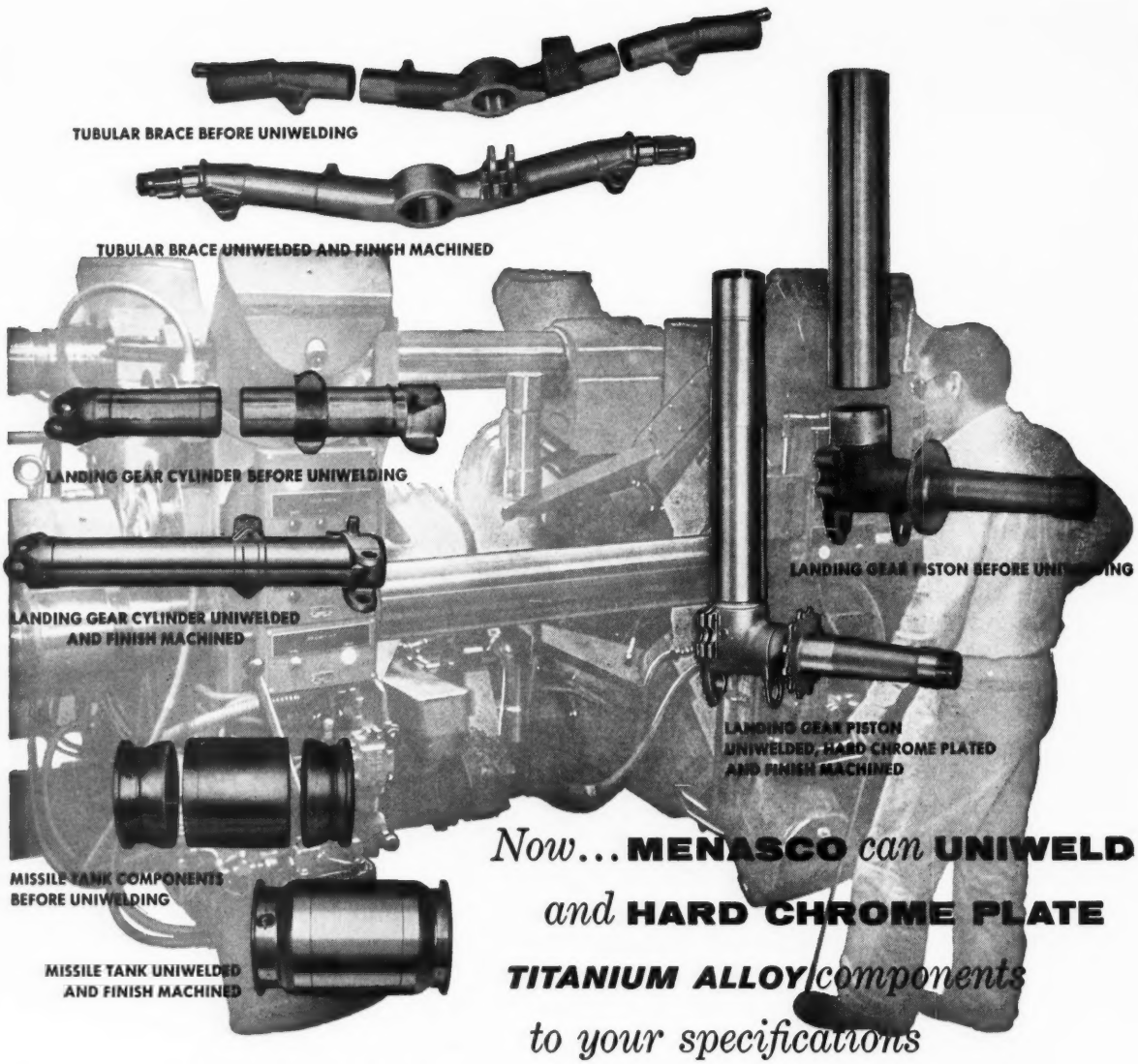
TUBULAR BRACE BEFORE UNIWELDING
TUBULAR BRACE UNIWELDED AND FINISH MACHINED
LANDING GEAR CYLINDER BEFORE UNIWELDING
LANDING GEAR CYLINDER UNIWELDED AND FINISH MACHINED
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LANDING GEAR PISTON UNIWELDED, HARD CHROME PLATED AND FINISH MACHINED
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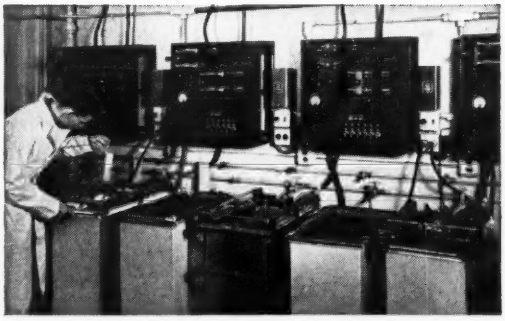
Illustrated are typical examples of what MENASCO can do with these two processes to fabricate titanium components for aircraft and missile applications.

Major aircraft manufacturers look to MENASCO for efficient engineering, product development and new fabricating techniques.

WHAT ARE YOUR REQUIREMENTS?



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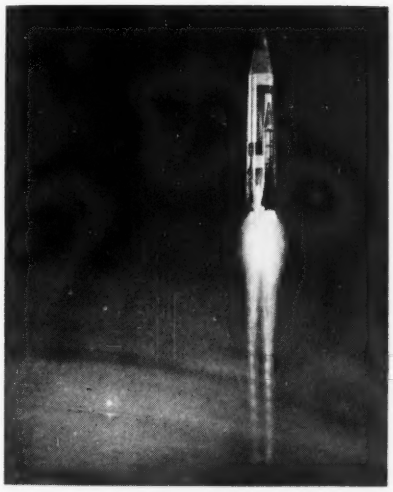


COVER: *"Atlas at 80,000 ft," a magnificent depiction of the Convair ICBM as it roars into space by artist Mel Hunter, well known for his paintings of rockets, guided missiles and space vehicles.*

Astronautics

MARCH 1958

The President's Letter

The tremendous growth of the AMERICAN ROCKET SOCIETY during the past year has brought with it a corresponding increase in member services.

Such services are designed to further the main purpose of the Society, as stated in our by-laws: "To aid and encourage by all suitable means the development and application of jet propulsion. . . rockets, guided missiles and space vehicles."

Toward this end, the Society distributes to each member its two monthly publications, ASTRONAUTICS and JET PROPULSION; makes available preprints of all technical papers presented at its four yearly national meetings; answers thousands of queries annually from individual ARS members; maintains an up-to-the-minute listing of books and films dealing with rocketry, jet propulsion and space flight; and encourages youngsters who show an interest in these fields.

Of major importance to the individual member are the 36 ARS Sections and 10 Student Chapters scattered throughout the country. Aided by ARS national headquarters in arranging programs, these groups hold about 400 local meetings a year, and provide a forum for learning about new developments, meeting fellow engineers and scientists and discussing problems. The personal contacts made at such meetings constitute perhaps one of the most important benefits to individual ARS members.

As ARS grows, more and more members are gaining the opportunity to serve in national as well as local offices, thus gaining valuable technical society experience, as well as prestige. Members also have every opportunity to participate fully in the affairs of the Society—to serve on technical committees, to present papers or act as chairmen or panel members at regional or national meetings, to suggest new projects, and to nominate candidates for ARS awards, as well as national officers and board members.

Individual members are herewith extended a cordial invitation to visit ARS national headquarters and get acquainted with the staff and the Society's services any time they happen to be in New York City.

George P. Sutton
President, AMERICAN ROCKET SOCIETY

The lessons of Peenemuende

The head of Germany's WW II military rocket effort reviews our own missile and space flight programs in the light of what was achieved at Peenemuende and urges immediate action to assure U.S. supremacy in these vital fields

By Walter R. Dornberger

BELL AIRCRAFT CORP., BUFFALO, N. Y.

In 1930, Walter Dornberger, then a Captain in the German Army and branch chief of the German Board of Ordnance, was given charge of the development of rockets as modern weapons. His first experimental station was set up at Kummersdorf, near Berlin, in 1931. Here, pioneering work was begun in the development of liquid rocket engines. From 1932 to 1945 he was at the same time division chief of rocket development, German Ordnance Board, and commander of the rocket development center at Peenemuende. In 1944 he became special commissioner for all V-weapons and antiaircraft missiles and at the end of the war held the rank of major-general. Dr. Dornberger came to this country in 1947 as a missile design consultant for the Air Force at Wright-Patterson AFB and joined Bell in 1950 in the same capacity. He is now technical assistant to the president of Bell.

WHEN, in 1930, the German Army started developing modern military rockets, there was not very much to build on. While the works of Ziolkowsky in Russia, of Goddard in the U.S. and of Oberth in Germany had stirred the imaginations of small groups of people in various countries throughout the world, none of the rocket groups in existence at that time could provide us with any reliable scientific or technical information.

The German Army—there was as yet no Air Force—was interested in rockets as weapons. In the absence of any extensive facilities where development work of this kind could be carried out, it was decided to start developing liquid rocket engines in our own military facilities.

Military Requirement Was to the Point

When I became head of the project in 1930, I received a three-line communique from my superiors listing the following military requirements:

"To develop in military facilities a liquid fuel rocket, the range of which should surpass that of any existing gun and production of which would be carried out by industry. Secrecy of the development is paramount."

That was all I ever got. From that point on, I was on my own. Contrast this with even the simplest military requirement that comes across your desk in this country today. It can, and very often does, run to as much as 250 pages or more!

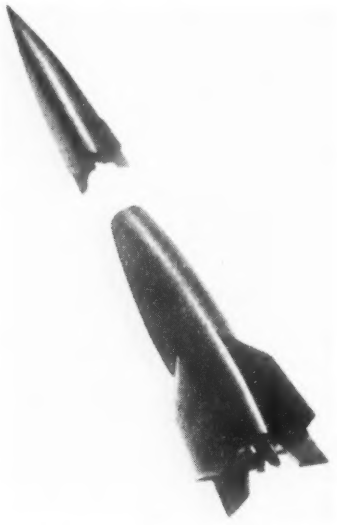
We began our work at a small proving ground near Berlin. We had some failures and some successes, but we proved that liquid rockets could be built. In 1936, after convincing the newly created Luftwaffe of this fact, we established the Rocket Experimental Station at Peenemuende as a combined Army-Air Force effort.

Equipped with all modern facilities—the first large supersonic wind tunnel, 440,000-lb thrust static test facilities, material labs,

THIS WAS PEENEMUENDE: Research, development, engineering, manufacturing up to the test series and actual testing were all carried out in an area of about 20 square miles.

V-1 LAUNCHING SITE
V-2 LAUNCHING SITE
AIR STRIP
V-2
TEST
AREA
LIQUID
OXYGEN
PLANT
DEVELOPMENT
LABORATORIES
V-2
TEST
STANDS
V-2
PRODUCTION
AREA
NORTH
MILES
0
1/4
1/2

V-2 (German A-4), largest operational missile of World War II, leaves launching stand.



A-9/10, a two-stage vehicle with intercontinental capability, was in development stage at war's end.

lox plants and big, modern workshops—the station covered an area of about 20 square miles and at its peak had more than 18,000 employees. Even more important, we could launch our rockets from sites not more than 2 miles from our manufacturing facilities.

Compare this with the present situation in the U.S., where large missiles must sometimes travel 2000 miles or more to Cape Canaveral for launching. This would be the equivalent of building missiles in Cherbourg, France, and launching them from the Russian launching sites on the Caspian Sea!

At Peenemuende, under ideal conditions, the A-3, A-5 and, later, the A-4 (or V-2, as it is called here), as well as the antiaircraft Wasserfall and a score of smaller and less important rockets, were developed. Research, development, engineering, manufacturing up to the test series, and actual testing were accomplished at this location, as well as training troops to handle the weapons. Mass production was later carried out in underground facilities outside of Peenemuende by German industry.

I'd like now to review briefly some of my experiences during 15 years at Peenemuende and contrast them with the present situation in this country.

Peenemuende Military Staff was Small

To begin with, Peenemuende was a military installation, with a military staff. However, this staff consisted of not more than four officers and approximately 20 staff members. All others—division and section chiefs, as well as laboratory heads—were civilians.

Peenemuende was organized like a large private research institute combined with a production plant. The administrative departments of the Army and Air Force had absolutely no control over Peenemuende. I personally was the court of highest appeal. I was responsible only to the Chief of the German Army, and there was no technical or military office in the Army or Air Force that had any say in the organization itself or in the development work going on there.

Today, in this country, there may be 20 or more offices in the Armed Forces which have a say in any missile project. Moreover, you may have to convince hundreds of different people if you happen to come up with a new project. Equally important is the fact that these people change every couple of years, which means it's enormously difficult to insure continuity of a project, since the people you have to satisfy are not only constantly changing, but also reluctant to make decisions.

As Peenemuende Commander, I was responsible for setting up the budget for the operation on a blank-check basis. In this country, budget problems can upset missile projects for months on end, as engineers and scientists whose main concern should be to get the job done spend long periods of time trying to justify the most obvious expenditures.

Peenemuende was the first weapon system organization in the world, set up to handle everything from research and development through mass production to training of troops in handling the weapons and supply for forward echelons. The entire operation was under a single commander who held down his post for 15 years.

Again, this is in sharp contrast to the present situation in this country, and points up the vital need for (CONTINUED ON PAGE 58)

U.S. IGY program to date

Achievements in field of rocketry during first five months of International Geophysical Year are outlined in a report by U.S. National Committee

ALTHOUGH the U.S.S.R. stole a march on the U.S. with its dramatic, but secret, launchings of Sputnik and Muttnik, the U.S. IGY rocket program has produced much valuable information during the first five months of the International Geophysical Year.

According to a recent report of the U.S. National Committee-IGY, the U.S. fired 81 rockets between the first test shot on July 5, 1956 at Wallop's Island, Va., and last November 30.

The 81 firings to date were conducted at Fort Churchill, Canada (nine Aerobees and five Nike-Cajuns); White Sands, N. M. (two Nike-Cajuns); Point Mugu, Calif. (13 Nike-Deacons); and in shipborne operations in the Arctic (18 Rockoons) and in Pacific and Antarctic waters (36 Rockoons). These firings have been productive of a great deal of important information about the upper atmosphere.

Some Preliminary Findings

Here is a review of some preliminary findings:

—The first atmospheric temperature maximum above Fort Churchill occurred at an altitude of 60 km, indicating that at northern latitudes the temperature rise is gradual.

—A rocket sent through a polar blackout for the first time revealed that a very dense D-region existed at a significantly lower altitude than was found heretofore, and with much greater density than is normally found at lower altitudes.

—The D-region of the ionosphere is primarily responsible for radio blackouts.

—Pressure and temperature distribution in the atmosphere at high altitudes differs greatly from that at lower latitudes. First density measurements made at high latitudes indicate that density of the high atmosphere is under strong solar control. There appear to be latitude, seasonal and strong diurnal effects.

—A mass spectrometer experiment confirmed beliefs that diffusive separation of gases under gravity is present above 100 km at high altitudes. Below this point, the gases in the atmosphere appear to be well mixed.

Other firsts were measurements of X-ray and ultraviolet bursts from the sun during solar flares

Signal Corps Aerobee-Hi firing at Fort Churchill. Preliminary findings based on such firings indicate 300-mph winds and temperatures of −100 F at an altitude of 60 miles.

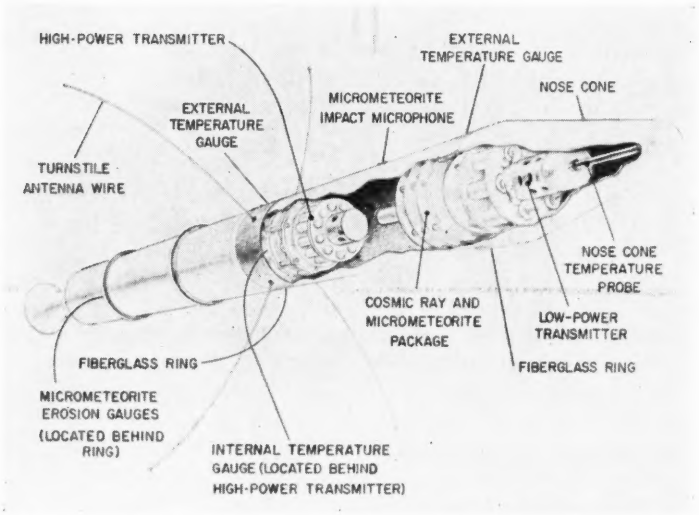
(February, 1958, ASTRONAUTICS, page 32); an excellent survey of auroral particles and their association with actual aurorae; and magnetic field measurements at high latitudes.

In addition to the Moonwatch satellite tracking program based on amateur participation, two other volunteer groups have been set up for tracking purposes. These are known as the Moonbeam and Phototrack programs. The former uses Minitrack Mark II and Microlock instruments developed by NRL and the Jet Propulsion Laboratory, respectively, and supplements primary Minitrack stations. The latter, organized by the Society of Photographic Scientists and Engineers, uses standard cameras of good quality to photograph the satellite.

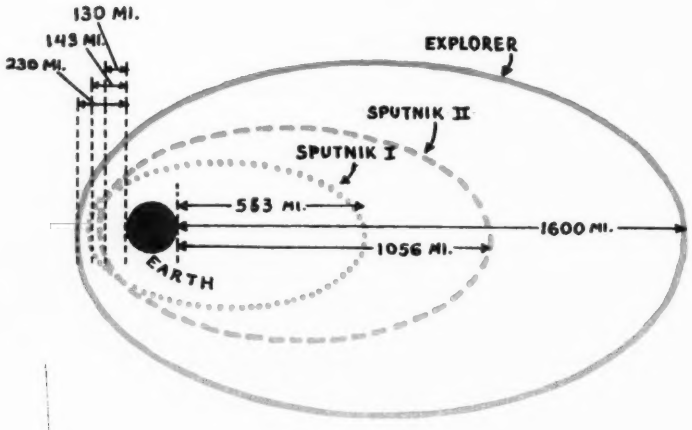
1958 Alpha—Made in U.S.A.

Army's Explorer, first American earth satellite, has already gathered valuable information and may remain in orbit for as long as ten years

AWAY SHE GOES: Army Jupiter-C gets off to perfect start on flight which launched the first U.S. earth satellite.



U.S. SATELLITE: It includes final stage rocket, as well as instrumentation.



ORBITS: How the Explorer's orbit compares with those of the two Sputniks.

RUNDOWN ON THE EXPLORER

LAUNCHING VEHICLE—Four-stage Army Jupiter-C, developed jointly by ABMA and JPL, with first stage powered by Redstone liquid propellant engine utilizing "Hydyne" high-energy fuel, and upper stages employing solid rockets furnished by JPL. Eleven second-stage rockets and three third-stage rockets are clustered atop the first stage, with the fourth-stage rocket-satellite combination protruding from a revolving bucket holding the second and third stages. Upper stages are spin-stabilized by means of electric motors mounted within first-stage nose section. Over-all length, 823.3 in. First stage is 672.8 in. long, 70 in. diam. $F = 78{,}000$ lb; $W_{GROSS} = 56{,}000$ lb; $t_{POWER} = 145$ sec.

PROGRAMMING—First-stage burnout occurred 150 sec after firing. This was followed by 240-sec coasting period which brought vehicle to approximate injection altitude. Firing of upper-stage rockets and separation of satellite from other upper stages was accomplished by means of ground signals. Upper stages were fired consecutively, each stage burning about 6 sec, to bring vehicle to orbital speed. Time from launching to actual orbiting, just over 7 min.

SIZE (Fourth-stage rocket plus satellite)—80 in. long, 6 in. diam

WEIGHT—30.8 lb, including payload instruments weighing about 11 lb

INJECTION ALTITUDE—About 200 mi

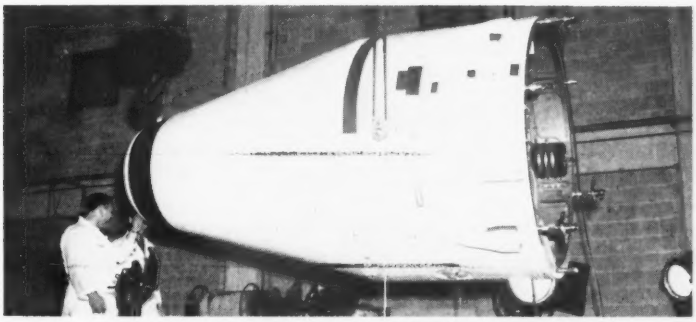
INJECTION ANGLE—About 33 deg to equator

ORBIT: Period— 114.95 min
Shape—Elliptical
Apogee—1587 mi (est.)
Perigee—219 mi (est.)

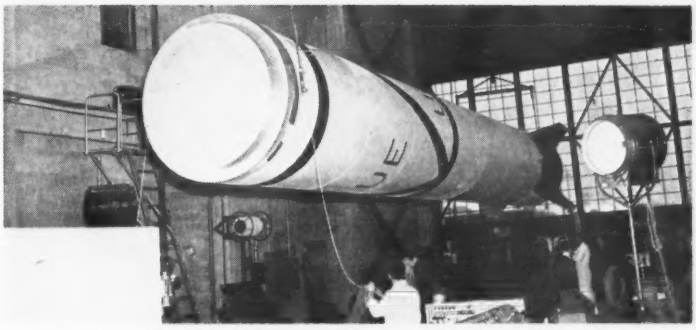
AVERAGE SPEED—15,000–18,000 mph

INSTRUMENTATION—External and internal temperature gauges; micrometeorite impact measuring equipment and erosion gauges; cosmic ray equipment; and low- and high-power radio transmitters, sending CW signals at 108 and 108.03 mc respectively.

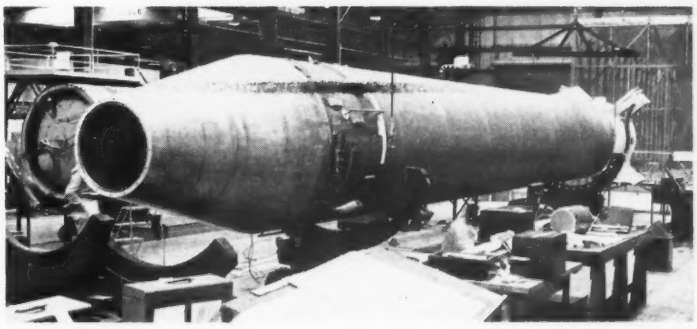
LIFE EXPECTANCY—3 months to 10 years



THE NOSE KNOWS: Modified Jupiter-C nose section, containing guidance system, is removed from trailer transporter at Cape Canaveral by ABMA technicians.

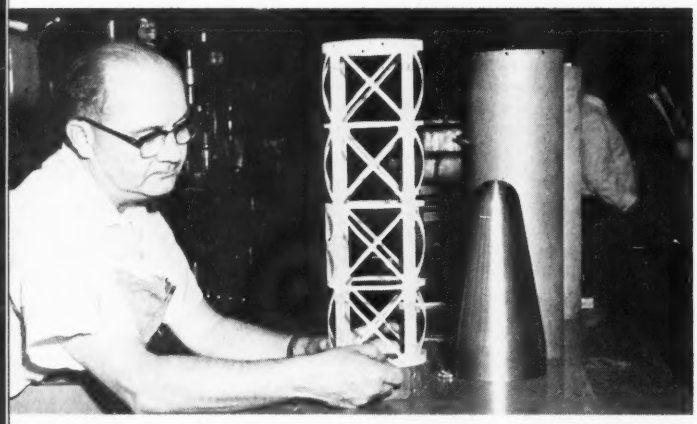


BOOSTER: Main stage booster, a Redstone, is prepared for checkout in ABMA assembly hangar at Cape Canaveral.



JOINED IN WEDLOCK: Main stage booster and nose section of Army satellite vehicle after mating.

SLEEVE: Fiber glass "lattice sleeve" which holds instruments is machined by Jet Propulsion Laboratory technician.

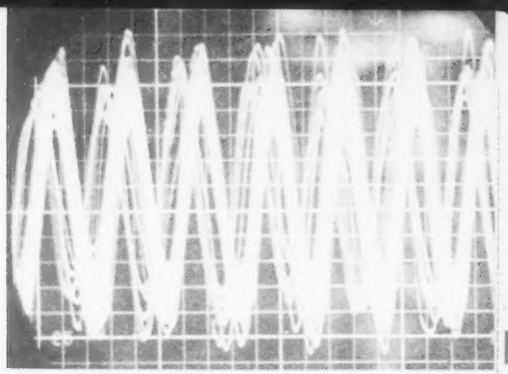


INSPECTION: Finished sleeve undergoes inspection at JPL. At right, thin steel case into which sleeve fits and nose cone.

TESTING: Instrument component is prepared for shake testing at JPL.

INSTALLATION: Instruments are placed within the sleeve and checked. Microlock transmitters can be seen at top and bottom of sleeve.

FINAL ASSEMBLY: Assembled satellite is positioned on "balancing tub" in spin test rig at Cooper Development Corp.



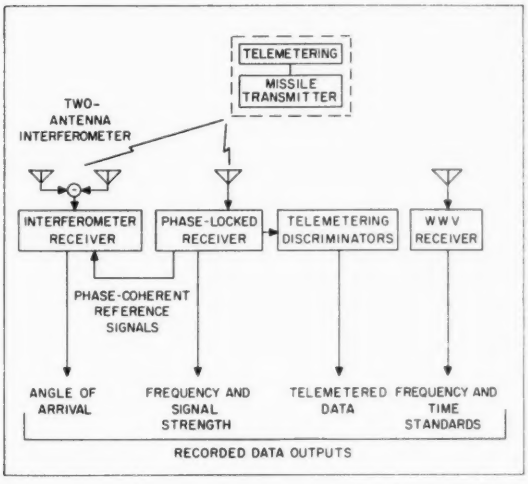
How Microlock works

Transmitter-receiver system of type used in Explorer, described in ARS paper, achieves low weight and power by transferring most of complexity to ground stations . . . Two transmitters use eight telemetering channels

EXPECTING that our first satellite would be too small for accurate tracking through conventional optical means, scientists at the Jet Propulsion Laboratory of the California Institute of Technology designed a low-power, lightweight transmitter and complementary ground-receiving equipment that would allow tracking of a small satellite regardless of light and weather conditions. The project, sponsored by Army Ordnance, led to the Microlock system now being employed in Explorer, the first U. S. satellite.

A description of the prototype Microlock system appears in a paper (ARS Preprint No. 550-57) by Henry L. Richter Jr., William F. Sampson and Robertson Stevens presented at the ARS 12th annual meeting in New York last December. The study for the prototype presumed a small satellite; a minimum line-of-sight range of 200 miles; instrumentation based on standard electronic techniques and available components exploited by good system design; a transmitter made low in weight and power by putting most of the system's complexity in the receiving station; and an angular-tracking error no greater than one milliradian.

PROTOTYPE MICROLOCK SYSTEM



Transmitter Parts and Potential

The transmitter developed for the prototype consisted of a radio frequency crystal oscillator phase-modulated by two telemetering subcarrier oscillators with encoded data. This transmitter weighed 2 lb with batteries and radiated 3 mw of radio-frequency power at 108 mc for three months. The transmitter could carry as many as five telemetering subcarriers at the cost of more weight. It transmitted omni-directionally.

Complementary ground equipment are centered in an interferometer antenna and a phase-locked receiver. The block diagram on this page shows the prototype Microlock receiving system.

Three broadband helical antennas formed this interferometer as a phase comparator. The antennas lay equispaced on a line. Signals from the end antennas led and lagged respectively the signal from the center antenna, and when added vectorially formed an interference signal with amplitude a rapid function of angle and with phase nearly identical to that of a reference channel. This interference signal would, as the angle to a satellite varied during its transit, show a variation nearly symmetrical in time. The interferometer would therefore give angular-position data that could be (1) correlated with the expected position of the satellite and (2) averaged over an entire transit of several minutes.

The prototype receiver had the ability to acquire and track the 3-mw (CONTINUED ON PAGE 41)

Why not dual-thrust engines?

Many of the disadvantages inherent in conventional booster-sustainer systems can be eliminated by designing a desired thrust program into a single solid propellant engine of the type now under development

By R. S. Newman

AEROJET-GENERAL CORP., SACRAMENTO, CALIF.

The author graduated from the University of California at Berkeley in 1948 with a B.S. in mechanical engineering. From 1948 to 1951, he was an apparatus design engineer with C. F. Braun & Co., Alhambra, Calif. He joined Aerojet in 1951 as a design engineer in the solid engine department and in that capacity worked on development of the Aerovahr, several versions of the Sparrow rocket engine, the D-40 and the Bullpup. He is now a principal engineer in the same department, in charge of development of Regulus boosters, the Bullpup, Falcon, Hawk and the 15NS-250 rocket engine for small aircraft standby power.

IT HAS LONG been recognized that thrust staging provides the most efficient means of powering a missile to a desired velocity within a desired length of time. Thrust staging means the application of thrust in a series of successive steps. This technique is commonly identified with ground-launched missiles, which must be accelerated from rest against gravity and high drag forces. Since air-launched missiles have the velocity of the launching aircraft as their "first-stage" velocity, and, since they are usually launched at higher altitudes where initial drag effects are reduced, thrust staging is not as common. But even in the air-launched application, two-stage designs are finding greater popularity.

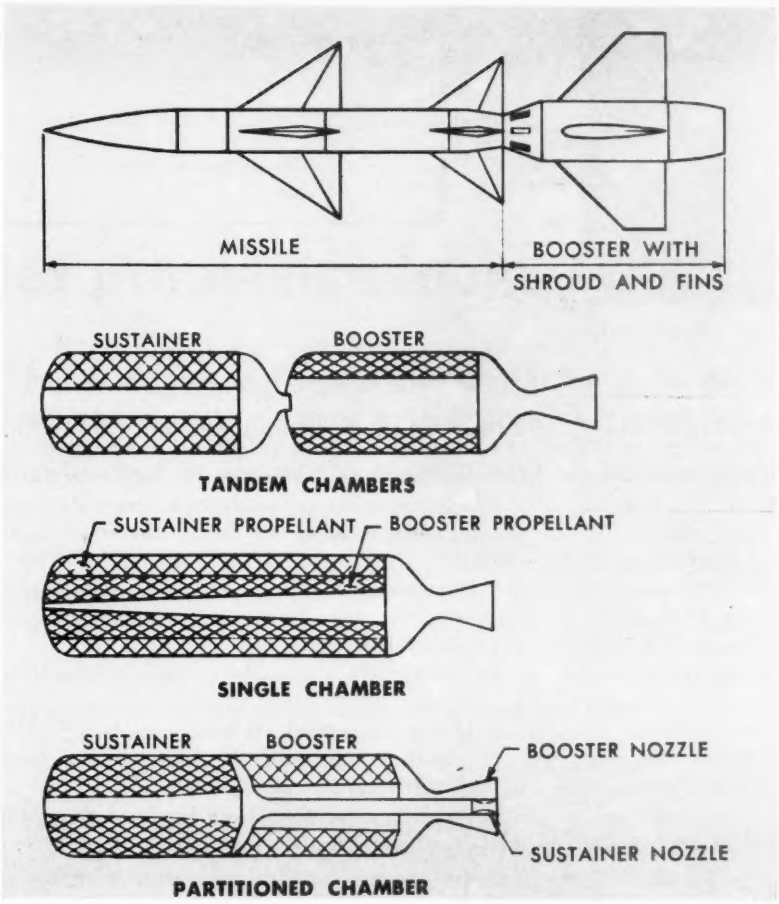
Functions of Booster and Sustainer

In this article, we shall consider only the two thrust stages, commonly called the booster and sustainer phases. The booster, or first stage, consists of the application of a high level of thrust for a comparatively short period of time. It rapidly "boosts" the missile to flying and maneuvering speed. The second, or sustainer, phase usually follows immediately after cessation of booster thrust, and provides a lower level of thrust for a longer period of time. The function of sustainer thrust can be to further accelerate the missile to a desired burnout velocity, from which the missile will "coast" to the target, or merely to maintain the velocity achieved at booster burnout by overcoming drag and gravitational forces for the length of time necessary to maneuver the missile as required.

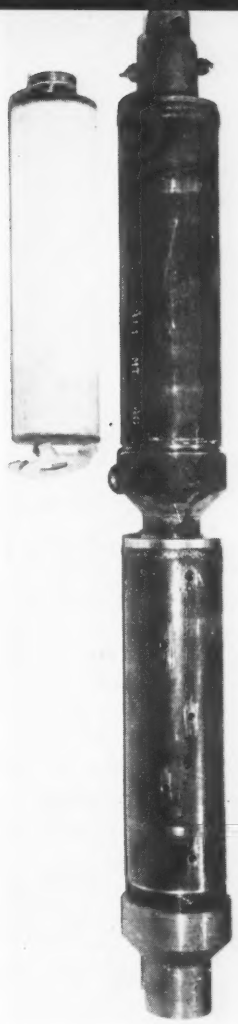
The traditional two-stage system consists of the missile with its built-in sustainer, which can be a rocket or a jet engine, and its booster, made up of one or more rocket engines which detach from the missile when they are expended. In many cases, it is either advantageous or mandatory for the booster to be an integral part of the missile, i.e., it does not detach itself when expended. When both the booster and sustainer are integral parts of the missile, the resulting powerplant is known as a dual-thrust rocket engine.

Before discussing some dual-thrust engines now under development, it would be worthwhile to understand why such an engine is

Based on a paper presented at the ARS Annual Meeting in New York, Dec. 2-6, 1957.



Conventional two-stage missile at top is contrasted with three basic dual-thrust configurations above.



An early experimental tandem-chamber engine.

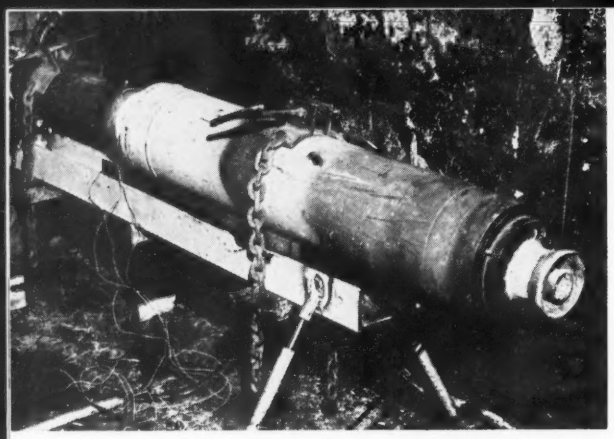
sometimes considered superior to the conventional booster-sustainer system. In the conventional system, the booster rocket is attached to the aft end of the missile in such a manner that upon cessation of booster thrust, the booster separates from the missile and falls to earth. A drawing of such a missile is shown on this page. It is usually necessary to provide a shroud for the booster, and it is common to equip the booster with fixed fins to aid in stabilizing the missile during the low-velocity boost phase.

There is an obvious advantage to this system. Jettisoning the booster and its attendant components relieves the missile of considerable mass—the expended booster chamber and closures, the shroud and attachment fittings, and the booster fins.

The problems involved, however, are numerous. Disposition of the booster can be a problem in both air- and surface-launched applications. The separated booster falling from an air-launched missile is a hazard not only to the launching aircraft but also to accompanying planes. On ground- and ship-launched systems, the falling booster endangers ground installations or other ships, unless it is made frangible and is blown into small pieces while falling.

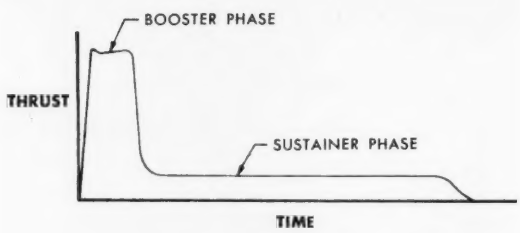
Separation Is a Problem

Separation itself is a serious problem. In the simplest systems, the booster is caused to separate merely by the effect of air drag when the booster stops firing and the sustainer ignites. It has been found, however, that in some systems, local air-flow conditions around the missile during flight are such that the booster will not separate in a reproducible manner, or will not separate at all. In these cases, it has been necessary to resort to ejection mechanisms to assure reliable separation. On one missile, the boosters are ejected by means of gas pressure bled from the booster themselves. On other missiles, such devices as small retarding rockets, explo-



Experimental partitioned-chamber, dual-thrust engine after firing.

IDEALIZED DUAL-THRUST FIRING CURVE



sive ejectors and thrust termination or reversal devices are employed. All these add weight to the missile system and, because of the increased complexity, reduce the inherent reliability of the system.

In addition to these disadvantages, there is the problem of assuring the proper ignition sequence. The sustainer must fire immediately after the booster ceases firing, so its igniter circuit may be closed by a timing device or by a device actuated by the physical separation of the booster from the sustainer. On many launchings of two-stage vehicles, booster operation has been satisfactory, but the sustainer, whether liquid or solid, has failed to fire. Many of these failures are attributed to the faulty sustainer-igniter actuating systems.

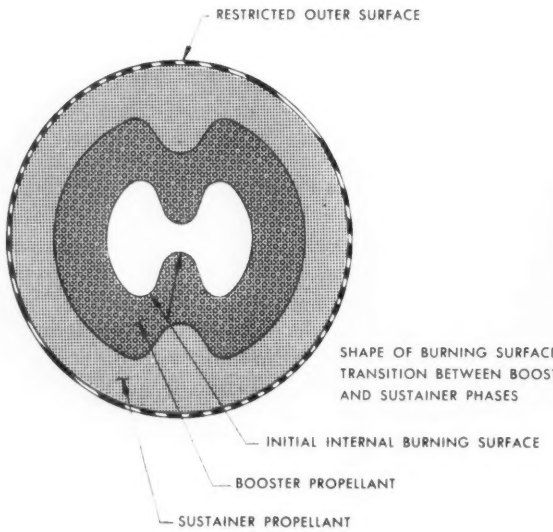
All these disadvantages can be eliminated by use of dual-thrust engines of the type now under development. The only ballistic disadvantage of the dual-thrust engine is that the extra weight of the larger chamber necessary to accommodate the booster phase remains with the missile after booster burnout.

Contemporary dual-thrust engine designs fall into three general categories of configuration, shown on page 27. These are:

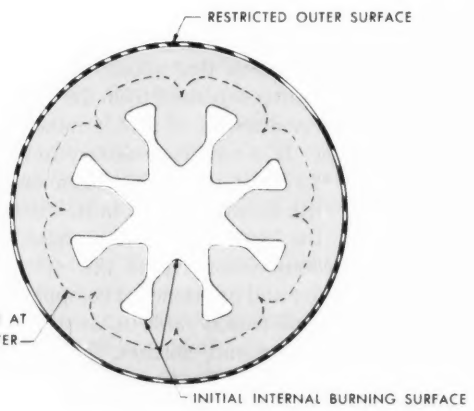
1. Two chambers in tandem, with one propellant in each chamber.
2. One or two propellants in one chamber.
3. One partitioned chamber with one propellant in each of the partitioned sections.

Each of these configurations produces the basic dual-thrust firing curves (CONTINUED ON PAGE 48)

DUAL-THRUST GRAIN DESIGNS



Two propellants, internal burning.


RESTRICTED OUTER SURFACE
SHAPE OF BURNING SURFACE AT TRANSITION BETWEEN BOOSTER AND SUSTAINER PHASES
INITIAL INTERNAL BURNING SURFACE

Single propellant, internal burning.

Jet propulsion looks to the future

Although a good deal of time and effort is being devoted to improving conventional powerplants, "hybrid" and unconventional engines are also being studied as the search for the ideal propulsion system continues

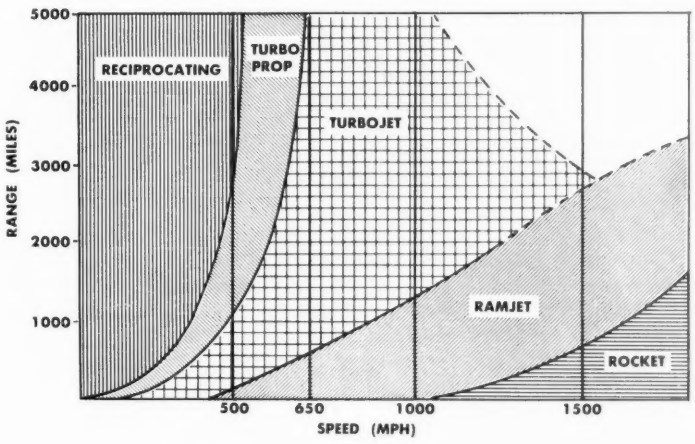
By Jerry Grey

PRINCETON UNIVERSITY, PRINCETON, N. J.

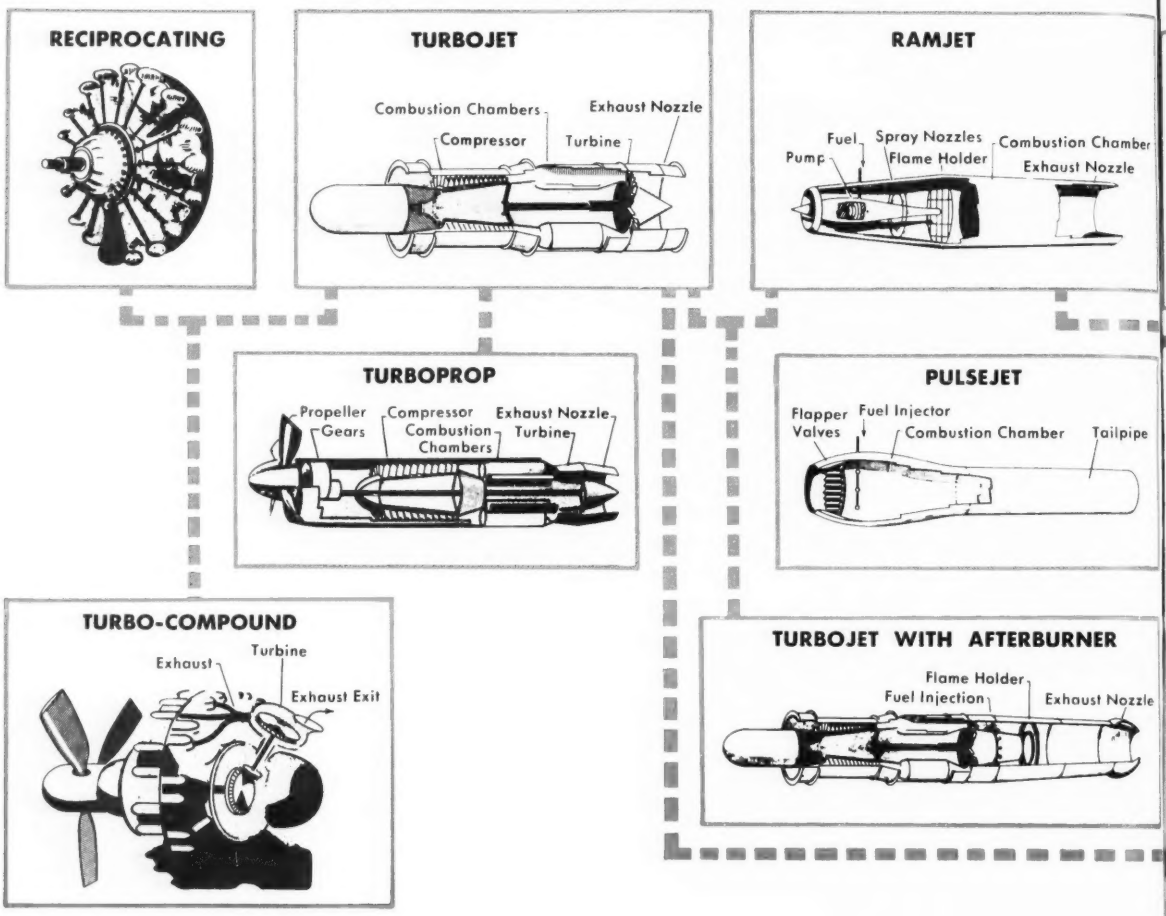
DESPITE the tremendous emphasis on jet engines today, the reciprocating engine is still the mainstay of American aviation, and likely to hold this top slot for some time to come. There can be little doubt, however, that modern speed and altitude requirements overwhelmingly favor the various types of reaction powerplants. An idea of operating ranges for the basic types of aircraft engines—reciprocating, turboprop, turbojet, ramjet and rocket—is given in the chart below.

Although rockets are always in the news these days, the gas turbine engines (turbojets and turboprops) are the unquestioned leaders in both development and application. According to the Aircraft Industries Assn., "the gas turbine principle will dominate the aircraft field at least as long as the piston engine—a tenure of more than 50 years."

Propulsion Spectrum—Basic Engine Types



Jerry Grey is now assistant professor of aeronautical engineering at Princeton. A graduate of Cornell University, he received his M.S. in engineering physics from Cornell and his Ph.D. in aeronautical engineering from California Institute of Technology. His past experience includes teaching thermodynamics at Cornell and work on the technical staff of Bell Laboratories, in addition to engineering positions with Fairchild Engine Div. and Marquardt Aircraft Co. He is at present a consultant to Potter Aeronautical Co. on aircraft instrumentation, to Atlantic Research Corp. on missile aerodynamics, to Reaction Motors on rocket combustion and to Aerojet-General on nuclear rockets.



The Gas Turbine

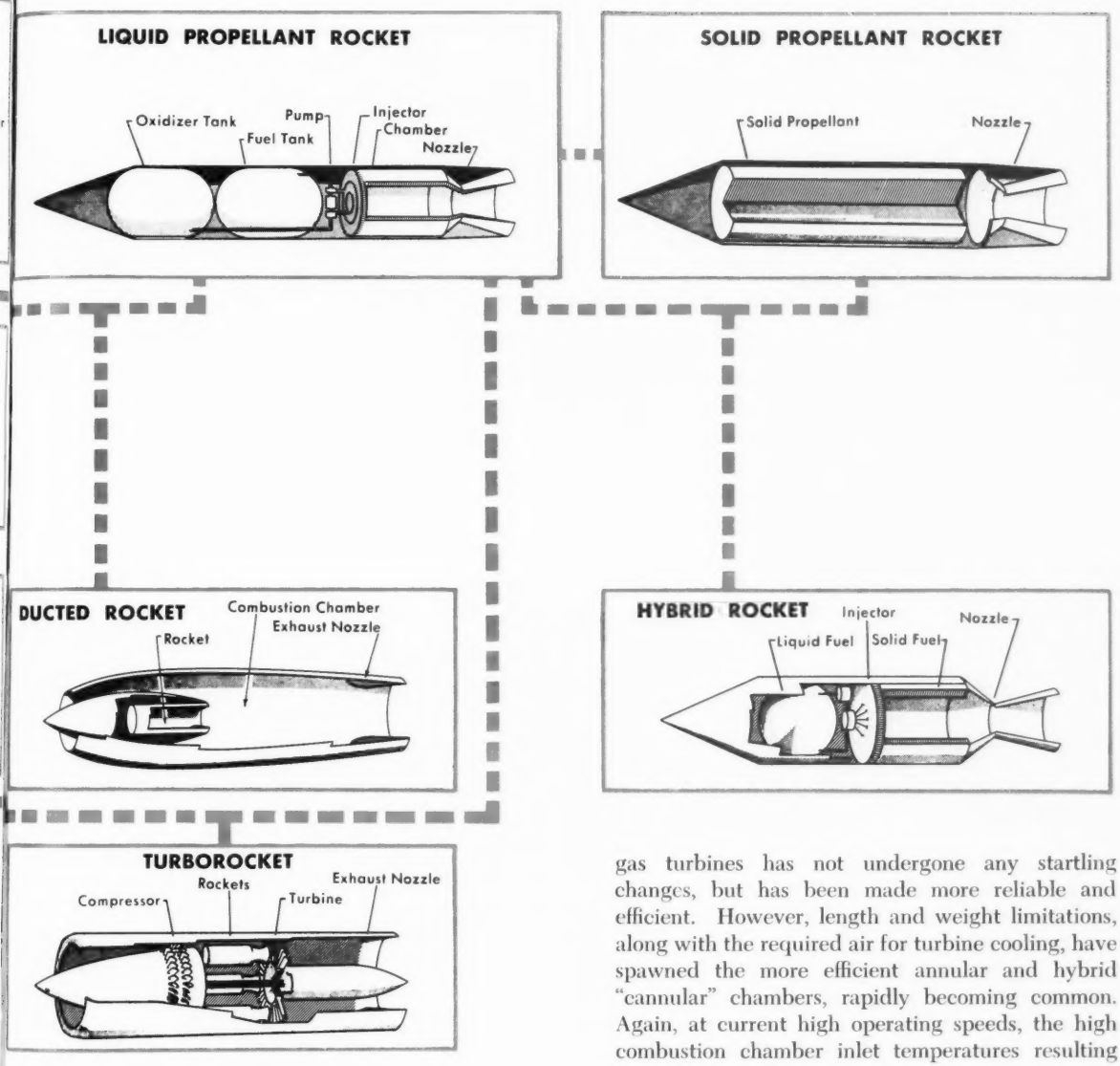
The ever-increasing need for higher thrust, lower weight and better economy has led to a number of major variations in the configuration of the basic gas turbine engine, centering on the five major engine components: Diffuser, compressor, combustion chamber, turbine and exhaust nozzle.

Development of the supersonic ramjet diffuser during the past decade provided the key to efficient turbojet operation in a range in which it was formerly inefficient, since at only moderate supersonic velocities, the diffuser provides as much pressure rise as the compressor. The present movable spike diffuser used in the B-58 engines is, however, only the first step in a program aimed at ultimate development of an adequately controlled variable-area diffuser with negligible shock wave losses. Such a diffuser is now being studied intensively by NACA for turbojet operation at Mach numbers as high as four, and will probably be applied in the new WS-110A long-range supersonic bomber.

Most of the early variations in the gas turbine powerplant, however, centered on compressor configuration. The first major change involved replacement of the original centrifugal compressor, with its large frontal area, by a multistaged axial fan. This change more than halved the frontal area required to provide a given thrust, and reduced drag correspondingly.

A second basic change saw the axial compressor rotor broken down into low- and high-pressure stages, rotating at different speeds and each driven by its own turbine assembly. This recent change made possible the very high thrust engines now running on many test stands and in operational aircraft. Even more recently, the use of variable pitch stator blades has brought a return to the lighter, less complex, single-spool compressor by providing efficient compressor operation over a wide speed range.

PROPULSION SYSTEMS



The final step in basic compressor design has been drastic reduction in both the number of stages and over-all pressure rise. This results from the high supersonic speeds now under consideration, at which most of the required operating pressure ratio is obtained from ram pressure through use of the more efficient diffusers discussed earlier.

In addition to basic compressor design changes, there have been many minor refinements and modifications, one of the more promising being the turbofan engine, in which only one compressor supplies the turbine, the other providing compressed air directly to the exhaust nozzle.

The can-type combustion chamber used in early gas turbines has not undergone any startling changes, but has been made more reliable and efficient. However, length and weight limitations, along with the required air for turbine cooling, have spawned the more efficient annular and hybrid "cannular" chambers, rapidly becoming common. Again, at current high operating speeds, the high combustion chamber inlet temperatures resulting from high stagnation temperatures permit much shorter chambers to be used. Further, use of other than hydrocarbon fuels (to be discussed later) has also considerably reduced over-all dimensions of the combustion chamber, providing a smaller, lighter engine for a given thrust.

However, the major change in "combustion chambers"—the use of heat exchangers rather than direct combustion of fuel to heat the air—is only in its infancy. Although many stationary gas turbine powerplants are of the closed cycle type, and hence require heat exchangers, the excessive weight of the exchanger has heretofore precluded its use in aircraft. With the advent of the nuclear reactor and its practically unlimited (CONTINUED ON PAGE 78)

Flight space and the satellites

With the launching of the first man-made "moons," international air law has entered one of its periods of major development . . . Immediate action is needed to determine the answers to the many legal problems they pose

By John Cobb Cooper

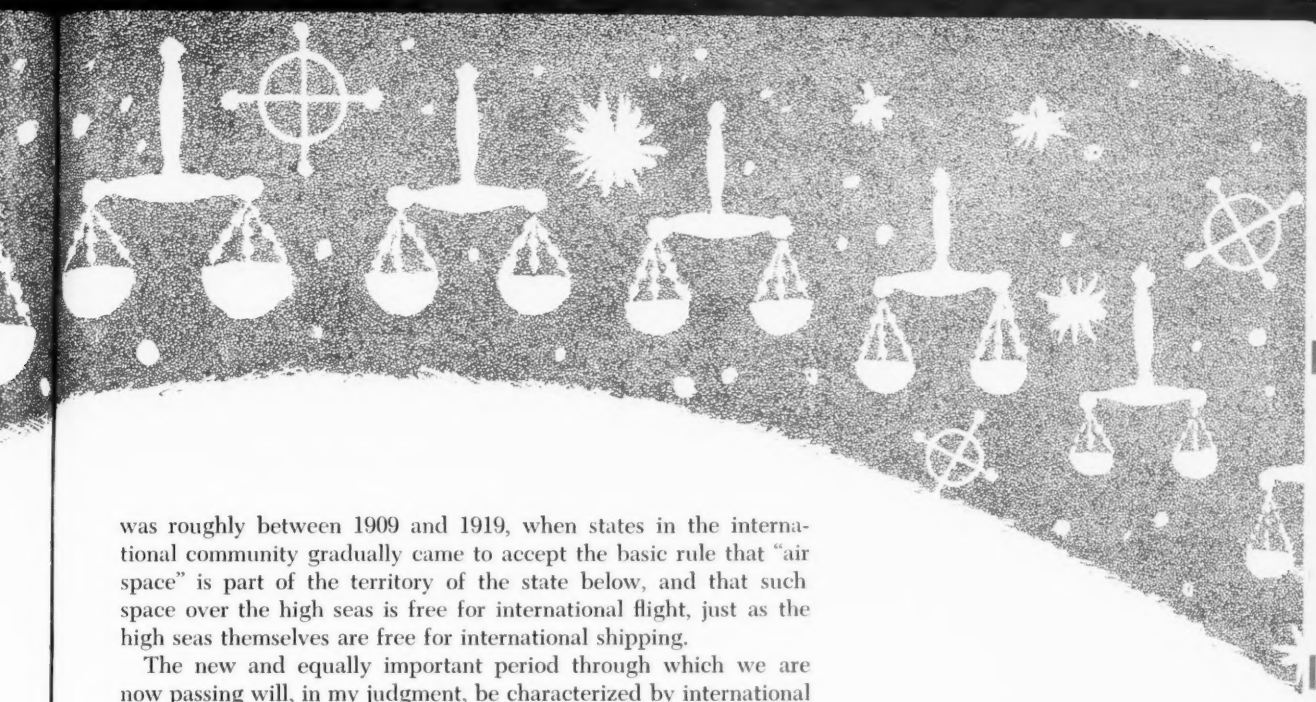
IN THE mind of the international lawyer, man-made satellites raise three problems of immediate importance:

1. What is the legal status of those areas of flight space used in the launching and eventual passage of the satellite?

2. What is the legal status of the satellite itself?

3. What international questions of future control of such flights and, indeed, of flight space itself, must be answered?

With the launching of the first man-made satellites, international air law, or, as I would prefer to call it, international flight space law, has entered one of its periods of major development. The last such period



was roughly between 1909 and 1919, when states in the international community gradually came to accept the basic rule that "air space" is part of the territory of the state below, and that such space over the high seas is free for international flight, just as the high seas themselves are free for international shipping.

The new and equally important period through which we are now passing will, in my judgment, be characterized by international acceptance of very definite upper limits on territorial sovereignty and the determination that all areas above such limits are free for the use of all states. This is the period of limitation of sovereignty, not of the creation of sovereignty.

"Flight" and "Flight Space" Defined

The term "flight space" was suggested by me in 1951 in two definitions put forward in an effort to simplify legal thinking in an era when rocket flight already existed and satellite flight was already foreseen, and when the term "air space" was rapidly becoming a vehicle for confused, rather than accurate, international thinking. These definitions were as follows:

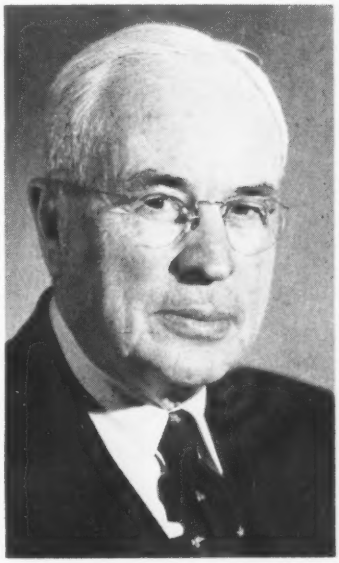
"Flight" includes any movement through space of man-operated or man-controlled devices or instrumentalities (to be known as "flight instrumentalities") such as balloons, dirigibles, airplanes, rockets, guided missiles or space ships.

"Flight space" means so much of universal space above and beyond the surface of the earth as is now used or may hereafter be used as the area in which flight takes place.

In an excellent article on international law and high altitude flights, Dr. Bin Cheng of University College, London, has revived the suggested term "flight space" and deals with it as consisting of two parts, namely "air space" and "outer space." The result may be the same as my earlier definition. His definition has the advantage of emphasizing the dilemma before us: Where is the boundary between the "air space," which is part of the national territory of the state below, and "outer space?"

Much has been written, but little has been decided, as to what is meant by "air space." It was certainly not discussed at the Chicago Conference in 1944. The drafting committee presented the present Article I of the Chicago Convention in almost the exact language of the Paris Convention of 1919, namely, every State has complete and exclusive sovereignty over the air space above its territory.

After many years of careful research, (CONTINUED ON PAGE 68)



John Cobb Cooper was professor of international law at McGill University in Montreal, Canada, from 1951 to 1957. A vice-president of Pan-American Airways from 1934 to 1946, Prof. Cooper was a member of the Institute for Advanced Study at Princeton, New Jersey from 1946 to 1951. At present, he is a member of the Air Law Committee of the International Air Transport Assn. and legal advisor to the International Air Transport Assn., as well as chairman of a committee of the International Astronautical Federation charged with preparing a statement for possible submission to the U.N. and the International Civil Aviation Organization regarding the extent of air space and resulting jurisdictional problems.

Omni-directional tracking systems

Combination of distance- and angle-measuring equipment permits instantaneous location of exact point in space of any missile within 200 miles

By Walter J. Zable

CUBIC CORP., SAN DIEGO, CALIF.

Walter J. Zable, now president of Cubic Corp., has had 18 years of experience in the administrative and technical aspects of electronics research, development and production. At what is now Convair, he directed a number of major projects in these areas, among them the original study program for Atlas guidance and electronic requirements; a study of long-range, glide-type missiles conducted after WW II; Azusa tracking and guidance system; and the Terrier simulator. Previously, as assistant to the vice-president, Control Instruments Co.; chief development engineer, Flight Research Engineering Co.; senior development engineer, Federal Telecommunications Laboratories; and senior development engineer, Sperry Gyroscope Co., he was responsible for various communications and radar systems, as well as Sparrow guidance and telemetry.

AS THE range and speed of missiles increase, the need for more precise and versatile missile-tracking systems goes up accordingly. This is especially true when the missile trajectory extends beyond the range of individual tracking units. Theodolite and radar tracking systems, for example, can follow a missile with great accuracy once they are locked on the target, but they are generally helpless in "finding" high-flying missiles crossing the horizon into their detection area.

These facts underlie the importance of the omni-directional tracking systems now being installed along the 5000-mile sea range off Cape Canaveral, Fla., and at the Air Force Armament Center, Eglin Air Force Base. These tracking devices, based on continuous wave techniques, are capable of locating, within milliseconds, the exact point in space of any missile within 200 miles. System accuracy is better than one part in 100,000, or 10 ft at the extreme limit of the range. Simple analog computing elements can be used to translate the information from these units into directional guidance for optical radar tracking systems.

Two basic building blocks are used to build up the new tracking systems. One of these is distance-measuring equipment (DME) similar to that now used in the guidance system of an operational ground-to-air missile. The other is angle-measuring equipment (AME) that provides a direction angle to the target accurate within 5 sec of arc at a range of 100 miles. These two units may be used singly or in combination to provide a wide variety of tracking functions.

Used Behind Canaveral Launching Pad

Perhaps the simplest application of the new approach to missile tracking is the use of a single AME directly behind the launching pad at the Air Force Missile Test Center at Cape Canaveral. This installation, given the name ELSSE (Electronics Sky Screen), provides the range-safety officer with immediate warning if the missile wavers to the right or left of a predetermined trajectory.

The theory behind the ELSSE installation is shown in the drawing on page 35. A single AME cannot pinpoint a target in space, nor even indicate its exact direction. Instead, it provides a

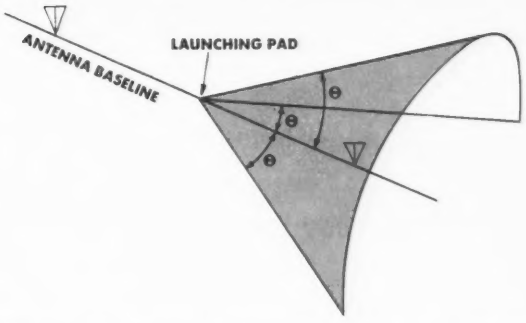
direction angle that traces, in effect, a conical surface. This is sufficient for the ELSSE purpose, however, and provides the safety officer with foolproof protection against "lost" missiles, even in weather conditions where visual, optical or even radar observation techniques may be impossible.

For actual tracking, however, a more sophisticated system is needed. This is illustrated by the two AME's and single DME now being installed on Eleuthera Island, approximately 200 miles downrange from the AF Missile Test Center. The two AME's are installed so that their individual cones intersect, as shown in the drawing on this page, and establish a single direction line to the target. This information may be used directly to guide optical and radar tracking devices, or, in conjunction with the distance information from the DME, the angle information may be used to provide a continuous record of the missile's exact path through space.

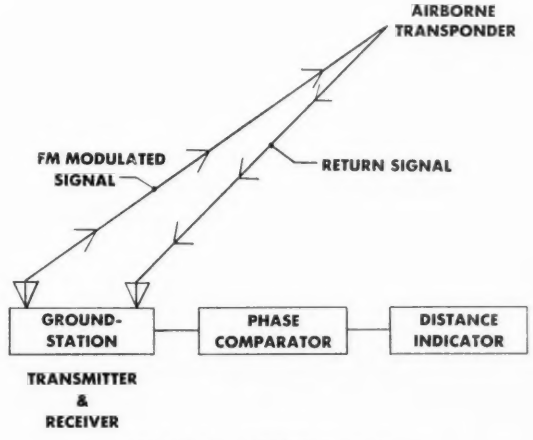
The combination of two AME's is known as COTAR (Correlation Tracking System), and the COTAR unit on Eleuthera is now in operation. The DME is scheduled for completion in the next few months. An additional COTAR is presently being installed on the Ascension Islands, 5000 miles from the launching base, where its omni-directional feature will be particularly helpful in picking up missiles approaching the target area.

Another combination that can pinpoint missile location is three or more DME's used in triangulation. Eventually, 11 of the units may be installed along the first few hundred miles of the Cape Canaveral range. A master keying system will activate individual DME (CONTINUED ON PAGE 46)

TRACING A CONE



Single AME measures direction angle, θ, between its antenna baseline and airborne transmitter, in effect tracing a cone.



Mechanics of DME Operation

$$R_1^2\left(\tfrac{L}{2}\right)^2+R^2+2\left(\tfrac{L}{2}\right)R\cos\theta$$

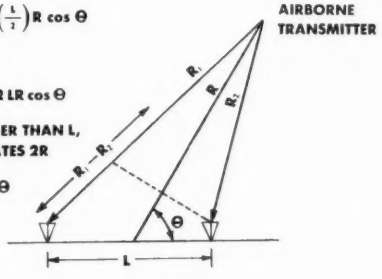
$$R_2^2=\left(\tfrac{L}{2}\right)^2+R^2-2\left(\tfrac{L}{2}\right)R\cos\theta$$

$$R_1^2-R_2^2=2LR\cos\theta$$

$$(R_1-R_2)(R_1+R_2)=2LR\cos\theta$$

IF R IS MUCH LONGER THAN L,
R_1+R_2 APPROXIMATES 2R

$$\therefore R_1-R_2\approx L\cos\theta$$

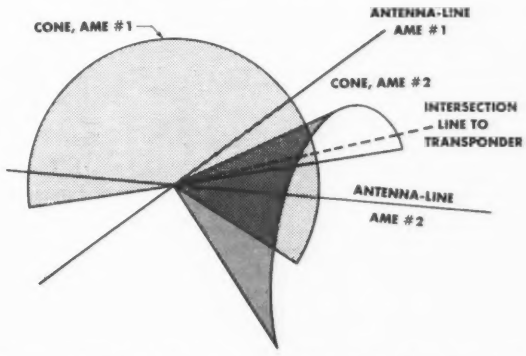


Mathematics of COTAR-AME

Channel	Frequency (kc)	Wave Length ft	Ft ($\frac{1}{2}$ cycle)
Very fine	491.76	2,000	1,000
Fine	61.47	16,000	8,000
Intermediate	7.684	128,000	64,000
Coarse	1.921	512,000	256,000
Very coarse	0.192	5,120,000	2,560,000

Characteristics of Modulation Frequencies

TWO AME'S=ONE COTAR



Two AME's installed at an angle to each other but with a common center point trace two intersecting cones, with line of intersection leading directly to airborne transmitter.

ASTRONAUTICS Report—Part One

AFCRC: Test tube for tomorrow

Vehicles and instruments for future upper air and space research, made-to-order weather and artificial "starlight" are among the many projects now under study by AF Cambridge Research Center's Geophysics Directorate

By Michael L. Yaffee

BEDFORD, MASS.—Twelve years and 20 miles from its nativity, the Air Force Cambridge Research Center sits amid the quiet, rustic surroundings of this historic New England village, out of place in its name and with its locale.

Here, scientists get together and talk of such things as sophisticated satellites that will weigh 100 lb and orbit at 4000 miles above the earth; ramjets that will take their fuel from the air; made-to-order weather; three-dimensional radar; the atmosphere on Mars; man-made ion clouds that will serve as signal relay stations; "invisible" contrails; communication and control transmission with pinpoint accuracy; and almost anything else related to earth or space.

Behind this talk is research in wave propagation, nuclear chemistry, aerosol physics, geomagnetics, thermal and electromagnetic radiation, high temperatures, ferrimagnetic ceramics, and other areas

BACKGROUND

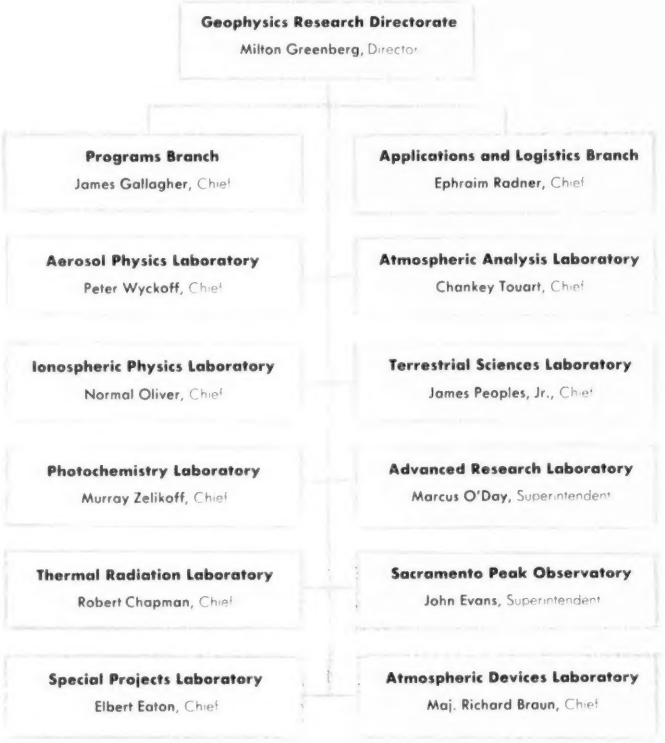
Nestled in the gently rolling hills surrounding Bedford Airport (the natives and road signs refuse to recognize it by its official designation, Laurence G. Hanscom Field), the Air Force Cambridge Research Center is 12 years old and shows all the growing pains of healthy adolescence.

Meanwhile, the scientists continue to carry out their work, some under the additional handicap of having to perform with split sections. Consolidation of AFCRC facilities is still not complete. Nevertheless, most section chiefs agree that it's a far cry from the first days of the Center.

AFCRC came into being shortly after World War II. With the war ended, MIT saw no reason to continue operation of its Radiation Laboratory, and Harvard decided to deactivate its Radio Research Laboratory. Both groups had been organized to do electronic research for the Army Air Corps and were staffed with some of the most capable and experienced men in the country.

The Army wanted to absorb these men into other laboratories, but few of them wanted to leave the academic atmosphere of the Boston-Cambridge area. So the Army set up a new electronics unit in Cambridge. This new facility was named Watson Laboratories, Cambridge Field Station.

In 1947, when the Air Force became an independent arm, Cambridge Field Station was taken from the Army and placed under the Air Materiel Command. In November, 1948, the Geophysics Research Division was transferred to Cambridge. And on July 5, 1949, the Cambridge Field Station was renamed the AF Cambridge Research Laboratories. The laboratories became the AF Cambridge Research Center in June, 1951, and were incorporated into the newly created Air Research and Development Command.



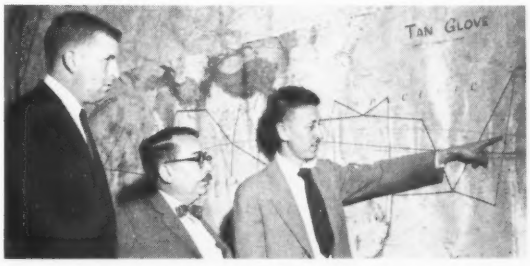
Under direction of Murray Zelikoff (left), group from Photochemistry Lab checks new time-of-flight spectrometer for analyzing composition of upper atmosphere.

Maj. Currie Downie details use of new Aerosol Physics Laboratory ice crusher to Lab Chief Peter Wyckoff (seated) and Charles Anderson.

where gaps in fundamental knowledge exist. Much of this research is carried out "in house," but a greater part of it is done under its direction at private and university research laboratories throughout the country.

AFCRC is unusual in that it has a double mission. Basic research in all aspects of geophysics is the function of the Geophysics Research Directorate, and in electronics, of the Electronic Research Directorate. While there is some overlapping, each directorate was established and still functions independently. Even in areas where their investigations cross paths, the approaches are generally different and often provide a means of cross-checking results.

To better understand the diversity of operations at AFCRC, let's take a step-by-step tour, first, through the table of organization of the Geophysics Research Directorate.



Path of Project Tan Glove, around-the-world research flight to pinpoint the geomagnetic equator, is retraced for Norman Oliver (center), chief of the Ionospheric Physics Laboratory.

Robert Chapman (in dark jacket), chief of the Thermal Radiation Laboratory, helps one of his groups with the thermal calibration of a high-speed telemetering system.

Work Is Close To Basic Research

The stated mission of GRD is to conduct research and development in the geophysical sciences to meet AF needs for geophysical information, techniques and equipment. Actually, the work at AFCRC is much closer to pure or basic research than that of most ARDC centers.

The director of GRD is Milton Greenberg. He reports directly to the commander of AFCRC, Maj. Gen. William Morgan, and is a member of the AFCRC Steering Committee. Gen. Morgan, in turn, is responsible to ARDC headquarters in Baltimore.

As defined by the Air Force, geophysical research is a broad subject encompassing "the planetary environment." To cover this vast field, GRD is divided into 12 groups under the director—nine laboratories, two branches and one observatory.

The two branches, Programs and Applications & Logistics, are essentially staff groups concerned with the directorate as a (CONTINUED ON PAGE 84)

Reason for smile on face of Maj. Richard Braun (left) is the solution to a balloon instrumentation problem that the men in his Atmospheric Devices Laboratory had been after for some time.

missile market

Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

IN POSSIBLE anticipation of the first successful American satellite, missile stocks were buoyed up in the month of January, occasioning a significant 8.2 per cent rise in the index. The Dow-Jones didn't even come close to this performance, although it managed to hold steady, mostly as a result of continued easing of credit.

In Washington, meanwhile, the speed-up in appropriations is continuing, with an additional $1.4 billion in new defense money to spur U.S. ballistic missile development receiving quick Congressional approval.

Aircrafts Dip

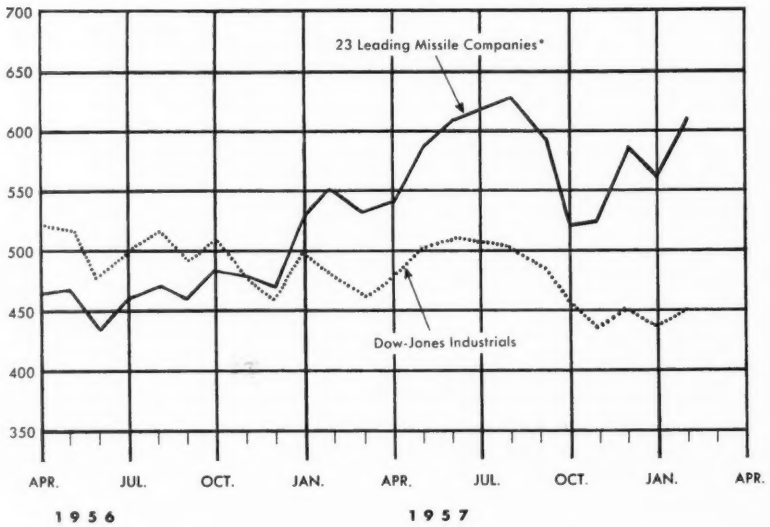
As far as aircraft manufacturers are concerned, of course, not everything is running smoothly. A few reports of lower earnings are being announced, with some reduced dividends following, but the real threat to investor confidence is a renewed round of renegotiation claims being filed by the Government on 1954 profits. Although the airplane makers are fighting tooth and nail against the whole concept of renegotiation, there is no doubt but that they will be forced to pay out significant sums in final settlement.

Of utmost significance to investors is the merger of Thiokol Chemical and Reaction Motors. Both stocks rose considerably on the news.

Although not as important from the investor's standpoint—because there is nothing he can do about it—but just as significant to the industry is the trend of missile makers to engage in joint-venture subsidiaries. Thus, North American Aviation and Phillips Petroleum have formed Astrodyne, Inc., a jointly owned firm which will specialize in the solid propellant field; Aerojet-General and Stauffer Chemical will work together on a development of boron-based propellants; and Thiokol and Callery will jointly develop solid-fuel rocket engines. Similar marriages will undoubtedly follow.

Recent economic news makes the investor's problem a simple one: Should he be more concerned about the present reality of a business recession or about the continuing long-term dangers of inflation? This column is still ideologically committed to the premise that nobody can "beat" the stock market and that long-term investments are in the last analysis the most profitable ones. We therefore continue to recommend carefully selected equities in the rocket and guided missile field, preferably chosen from among some of the smaller and more nearly "true" missile companies.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	February 1958	January 1958	% Change	February 1957	% Change
Dow-Jones Industrials	450	439	+2.5	479	−6.1
23 Missile Companies	609	563	+8.2	552	+10.3

Market Letter Gleanings

The following $12,000 portfolio of missile stocks "promises to substantially outperform the general market in the period ahead," according to Granger & Co.

No. of Shares	*Security*
50	American Bosch Arma
50	Cook Electric
15	Douglas Aircraft
20	General Dynamics
35	General Tire
70	G. M. Giannini
25	Litton Industries
25	Lockheed Aircraft
40	Marquardt Aircraft
30	Martin Co.
30	North American Aviation
15	Thiokol Chemical

American Potash & Chemical—"In our opinion, present appraisals accord virtually no premium for the company's stake in high-energy fuels. It is for this reason that we again recommend the stock for the speculatively minded interested in possible large capital gains over the next several years." (Hirsch & Co.)

"We believe that the stock of *Thompson Products*, at currently relatively depressed levels, represents an attractive purchase for long-term price appreciation." (Fahnestock & Co.)

"*Litton's* stock offers the investor an interest in a successful company and in the unlimited future of advanced electronics. We believe that portfolios designed for capital appreciation should have a strong participation in Litton Industries." (Filor, Bullard & Smyth)

"In view of the bright future prospects for the Electra, the company's basic position as a major producer of manned aircraft and the rapidly growing missile business, the shares of *Lockheed Aircraft* appear to offer ap-

(CONTINUED ON PAGE 74)

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Is it possible to build a **MAN?**

"Theoretically, yes," said the scientist. "Or a reasonably remarkable imitation—a kind of mechanical analogue. Call it a habit machine, a mechanism operating according to the laws of the conditioned reflex."

You mean that you could actually build a mechanical mind? One that would exhibit emotions—such as love, fear, anger, loyalty?

"We're doing something like that now in advanced missile development," the scientist replied. "In a limited, highly specialized way, of course."

"Take the 'pilot' that is being developed for the big long-range missile. *He* has a wonderful memory, and can solve many complex navigational problems in a flash. *He* loves perfection, and actually becomes highly excited when *he* gets off course. *He's* a tough-skinned character, impervious to the cold at several hundred miles altitude and the incredible heat at re-entry. And *his* loyalty is heroic. *His* life is a single mission, the mission *his* whole life... and maybe ours, too. *He's* a pretty important *fellow.*"

What about the complete man-made Man? What would that entail?

"A mechanism the size of the capitol in Washington, and the best scientific resources in the world. But it could be done. You see, it's only a question of how physical matter is organized. As a great biophysicist explained, 'If material is organized in a certain way, it will walk like a man. If it is organized in another way, it will fly like a missile.'"

Still, wouldn't there be something missing in the complete man-made Man—something very important?

"Yes," said the scientist. "A soul."

MARTIN

BALTIMORE·DENVER·ORLANDO

How Microlock Works

(CONTINUED FROM PAGE 25)

signal at a line-of-sight range of 3000 miles and at any azimuth and elevation if the ambient noise level was not too high. Receiving, timing and recording equipment for a complete ground station could be worked from a 25-ft semitrailer. Critical parts were designed as a few subassemblies that could be replaced quickly and easily.

Explorer carries two Microlock transmitters of advanced design, each with four telemetering channels. One transmitter radiates 60 mw at 108.03 mc and will last two to three weeks. The other radiates 10 mw at 108.00 mc and will last two to three months. Ham radio operators will be able to receive the 60-mw signal. Minitrack and other special receivers will be necessary for the weaker signal.

Data to be Gathered

Through the radio link of Microlock will come information on cosmic rays, meteorites and temperature in the skin and instrument compartment of the satellite.

Both transmitters will broadcast the cosmic-ray count of a Geiger-Mueller tube by showing one frequency pulse for 32 cosmic-ray impacts, which is the rate of impact expected per second. The satellite can thus better record fluctuations in the rain of cosmic rays, such as would be caused by solar or magnetic storms.

Both transmitters will also broadcast evidence that meteorites have struck the satellite. The 10-mw transmitter will be pulse-modulated when any of 12 wires forming an erosion gauge near the nozzle end of the satellite breaks under the impact of one or more meteorites. The breaking of a wire will be taken as a sign that a meteorite 5 microns or greater in diameter struck the gauge.

The 60-mw transmitter will be pulse-modulated when a meteorite of considerable size and momentum strikes the satellite anywhere. Attached by a spring contact to the satellite shell is an impact microphone that causes the frequency of the 60-mw transmitter to shift from low to high in the band when a large meteorite strikes. On the other hand, the frequency will be caused to drop from high to low when either a large or small meteorite strikes. Analysis of the high and low periods will indicate distribution of impacting meteorites by relative size. An estimate of the real size and momentum of a meteorite will be made in terms of calibrations selected for the several instruments.

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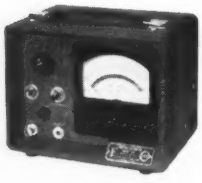

MODEL 14A, TRUE RMS A-C VOLTMETER — 0.5 mv to 200 v full-scale. Response: 10 cps to 500 kc

MODEL 20A, TEST OSCILLATOR —15 cps to 150 kc-less than 1-ohm output impedance

MODEL 30A, D-C ELECTRONIC VOLTMETER — 8 ranges — 0.05 to 150 volts d-c Scale zero-centered

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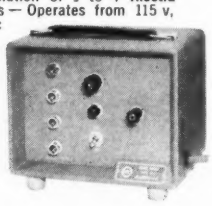

telemetering channels. The other four channels monitor temperatures: (1) Inside the instrument section, (2) on the skin at the fiber glass ring between the instrument section and the rocket motor, (3) on the skin at the fiber glass ring between the instrument section and the nose cone, and (4) inside the nose-cone tip resulting from aerodynamic heating during the flight to orbit. This temperature data will be immediately useful in the design of other satellites.

Microlock will broadcast some of the most important data ever garnered by scientists. Moreover, simply by inhabiting Explorer with a trackable signal, it will introduce our first appreciable direct knowledge of the ionosphere, geomagnetic field intensity, and atmospheric density at great heights. And it will allow measuring for the first time exact distances between continents and perhaps give an answer to the long-standing question: Do the continents drift?

Microlock thus takes a noteworthy place in the technology of the past two years and is our first excursion into space.

Missile Div. Formed By Chrysler Corp.

Formation of a new Missile Div. has been announced by Chrysler Corp. The division, to be headed by C. Allan Brady as general manager, will be responsible for Chrysler participation in development, engineering and production for the Army's Redstone and Jupiter programs.

Brady, formerly operating manager of Chrysler Missile Operations, will report to Irving J. Minett, corporate group executive in charge of the new division. Minett will continue to direct the Chrysler Defense Operations Div.

Thiokol, Reaction Motors Boards Agree to Merger

The boards of directors of Thiokol Chemical Corp. and Reaction Motors, Inc., have agreed to a merger of the two companies. Proposed terms of the merger, subject to stockholder approval, call for RMI holders to receive one share of Thiokol's new stock for each $1\frac{1}{4}$ shares of RMI stock held.

The merger brings together a pioneer liquid propellant engine company (RMI) and a leading solid propellant firm (Thiokol), and means Thiokol's present plants in Maryland, Texas, Alabama and Utah will be augmented by RMI facilities in Denville, Rockaway and Lake Denmark, N. J.

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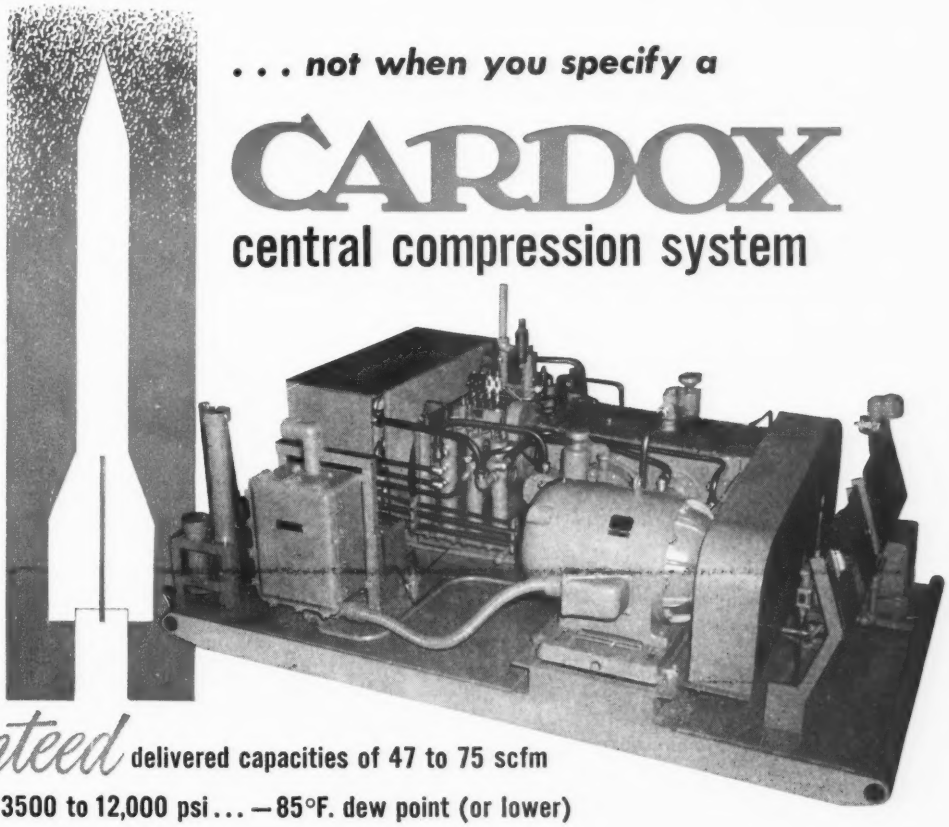

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in print

Rockets Through Space by Lester Del Rey, The John C. Winston Co., Philadelphia, 118 pp., illustrated by James Heugh. $3.95.

This is a book about rockets and space travel for young people. The age of prospective readers for whom it was written is not specified, but I should judge it would have a very considerable appeal for youngsters from 12 to 18, and even for older people who would like a quick and easily understandable review of the subject.

Mr. Del Rey is a science fiction writer of note. He has obviously made a study of the literature of rockets and space flight, especially the books and articles of Willy Ley and Wernher von Braun. A good many of the ideas he expounds are strongly influenced by these writers, and so is the historical treatment of the subject, which gives major credit for the development of modern rockets to the Germans, and dusts off the basic pioneering work of Robert H. Goddard with a single paragraph, in which Mr. Del Rey says: "As early as 1920, the American, Robert H. Goddard was doing some work with rockets in an attempt to find a way to explore the higher stratosphere, but nobody paid much attention."

He gives credit to the Germans for developing the regenerative liquid fuel rocket motor, omitting to make any mention of the fact that James H. Wyld of the AMERICAN ROCKET SOCIETY did it first. He suggests that the first liquid fuel rockets were flown by the Germans in 1931, and ignores Dr. Goddard's pioneer liquid rocket shots of 1926–1929 and later. He gives credit to Oberth for the step-rocket idea, overlooking the fact that Goddard proposed step-rockets in his Smithsonian Report of 1919, and actually obtained a patent on the idea. As to the AMERICAN ROCKET SOCIETY, Mr. Del Rey says that, during the '30's, the members "were doing some work, but nothing of importance came from their efforts."

Aside from the inadequately researched historical section, the book suffers, as do many now appearing, from having been written in the pre-Sputnik days. For that reason, some of the early chapters, especially those dealing with satellites, seem a bit naive. There is also a curious apparent confusion of the Vanguard satellite project with Fred Singer's MOUSE proposal.

But it is too easy to overemphasize these details. The main portions of the book, especially the four sections that deal with the nature of space and how it will be conquered, are very interesting and informative, and are so well and simply written they should be within the grasp of any reasonably alert youngster. In addition, the book is superbly illustrated, with drawings and colored illustrations that further clarify the text, and make space flight seem very real and imminent indeed.

—G. Edward Pendray

Practical Astronomy by W. Schroeder, B.A.A., Philosophical Library, New York, 1957, 206 pp., illustrated. $6.00.

This book is an introduction to many of the basic concepts of astronomy, written in popular language for the layman. It is totally devoid of the rigorous mathematical formulas of spherical astronomy. A knowledge of arithmetic and geometry is sufficient for its comprehension. No trigonometry is used.

The book fulfills a real need of the lay public for an understanding of the heavens. It includes an introduction to the principal constellations, various coordinate systems, the apparent motions of the stars and when and where to find them, diurnal and seasonal effects, how to tell the time of night by the stars, how to calculate the various kinds of time, the astronomical triangle and its relationship to celestial navigation. There are instructions on how to make an astrolab and examples of its use in graphically solving various practical problems. Also, the use of a celestial globe is described. The examples are chosen for England, but the principles are applicable to other latitudes.

The parameters of planetary orbits are defined and illustrated. Kepler's Laws are stated. A welcome feature one seldom sees in other books is circular diagrams showing graphically the longitudes of perihelion and ascending node with respect to the First Point of Aries for each planet from Mercury through Uranus.

The motions of the moon are described and illustrated with diagrams. Eclipses and their cycles are explained.

Chapter 14 describes how to choose and assemble some small lenses to make a simple telescope, and also how to construct a simple equatorial mounting. Chapter 15 describes how to use the small, simple telescope, and what to see with it. Chapter 16 lists and describes 140 interesting stellar and nebular objects which can be observed with a small telescope.

The book is profusely illustrated with star charts and diagrams. It might well serve as a guide to various laboratory exercises in a beginning course of astronomy.

In an age of flying saucers and artificial satellites, more worthwhile observations could be reported if observers took the trouble to study and understand the contents of this book.

—CLYDE W. TOMBAUGH
New Mexico College of Agriculture and Mechanic Arts

BOOK NOTES

Lloyd Mallan's "**Space Satellites**" (Fawcett Books, $0.75) is the first of what promises to be a flood of low-priced paperbacks attempting to cash in on growing interest in rockets, satellites and space flight. While hurriedly put together, this 144-page book, authored by a top science writer whose previous efforts in this field have been very well received, offers good value for the money and provides an excellent introduction to the subject.

Boasting an introduction by Andrew G. Haley, IAF President and ARS General Counsel, the book is a catch-all, roaming from a complete description of the Vanguard vehicle to such subjects as tracking operations, how to build a Moonwatch telescope, how satellites will affect our lives, even to the point of bringing reduced taxes and lower food costs(!), background material on rockets that led the way, the Soviet satellites, new propulsion systems and even Lockheed's proposed "Big Brother" satellite project.

While a few "bloopers" have crept into the text, the many illustrations and the vast amounts of factual material contained in the book make it a good investment for laymen seeking information on the subject.

—I.H.

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Stauffer-Aerojet Co. has been set up as a joint venture by Aerojet-General Corp. and Stauffer Chemical Co. to develop and produce boron compounds. Business will be conducted principally at Azusa, Calif., corporate headquarters of Aerojet.

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Omni-directional Tracking

(CONTINUED FROM PAGE 35)

stations to provide continuous coverage as the missile progresses down range.

The common denominator between the AME and the DME is that both are based on phase-measurement techniques, and both make use of a missile-borne transmitter. The latter, in case of the DME, is part of a missile transponder, keyed to a transmitter on the ground at the instrument site. In both cases, the signal is a continuous wave at RF frequencies and may therefore also be used for telemetering information to or from the missile.

The DME ground transmitter signal may be used, for example, to transmit guidance commands to the missile, and the missile-borne transmitter may be used to telemeter operational flight data. The result is important savings in electronic complexity and weight. In fact, the tracking data may almost be viewed as "free" information.

A simple block diagram showing how the DME operates will be found on page 35. A continuous-wave FM signal, carrying distinctive modulations, is transmitted from the ground to an air-borne transponder. The transponder returns with a second FM signal, at a different carrier frequency, but with the same distinctive modulations received from the ground. There is a time lag, however, between the time an individual frequency modulation is transmitted from the ground and the time it returns. This delay is, of course, directly proportional to the distance between the ground station and the missile.

Five different modulation frequencies are combined in the one signal to resolve the conflicting demands of non-ambiguity and accuracy. The characteristics of these five frequencies are outlined in the table on page 35, which shows that the lowest modulation frequency, 192 cps, has an effective wave length of 5,120,000 ft, or nearly 1000 miles. There is no chance, therefore, that, within the 200-mile range of the equipment, an ambiguous shift in phase of more than one cycle can occur.

Purpose of Modulations

The 192 cps modulation is non-ambiguous, but at the expense of accuracy, since the inherent error in the phase comparison circuitry acts across the entire 1000-mile wave length. The purpose of the other four modulations is to provide increasingly precise measurement—with increasing chance of ambiguity. The "very fine" modulation, for example, has an equivalent wave length of only 2000 ft, which results in a complete phase shift for every 1000 ft of slant distance to a target. Assuming a maximum error of less than 1 degree in measuring the phase shift, using an electromechanical servo-phase meter, this means a potential accuracy of better than 3 ft, no matter what the range. But since the phase shift repeats itself every 1000 ft, there are over 500 chances of ambiguity if the range is in the neighborhood of 100 miles.

The conflicting problems of ambiguity and accuracy are resolved by using five-phase-comparison mechanisms, one for each frequency modulation, all connected in a single gear train leading to the read-out indicator. The "very coarse" phase-discriminator drives the gear train till it has been brought within the ambiguity limits of the "coarse" discriminator, at which point the latter takes control. The process repeats itself through the other frequencies. The servo moves, at very high speed, until the "very fine" discriminator takes permanent control for continuous tracking of the missile.

Measurement of phase differences is also the key to the AME operation, but in this case the phase shift is in the signals received by two antennas and receivers separated on the ground, tuned to a single transmitter in the missile. This phase shift is proportional to the distance R_1-R_2 shown in the drawing on page 35, which in turn is proportional to the cosine of the direction angle.

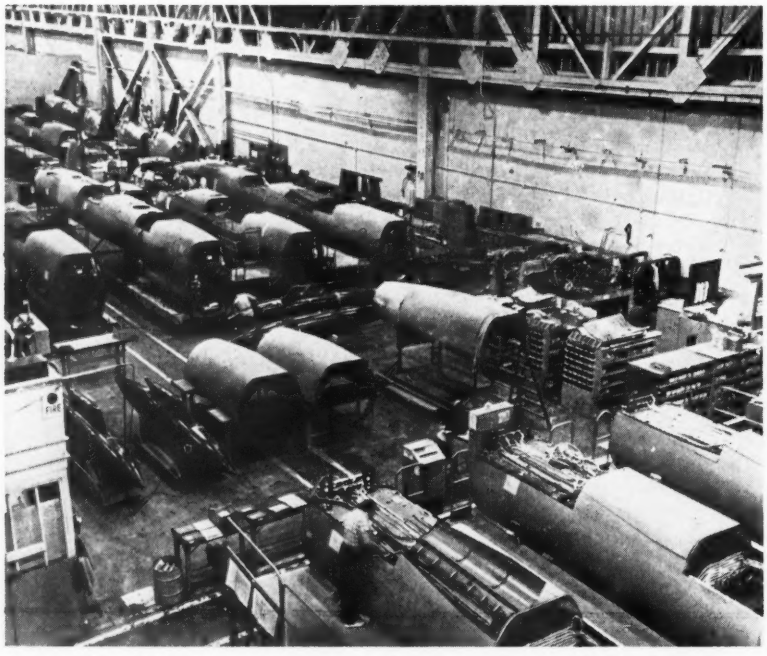
Again, ambiguity and accuracy conflict, since a long base leg between antennas increases accuracy but also increases the chances of ambiguity. The solution in this case is to use three sets of antennas, spaced distances equivalent to one-half, five and 10 wave lengths. A common gear train connected to a single display again provides a fail-safe method of resolving the ambiguity-accuracy problem.

Character of AME-DME Signals

The continuous-wave character of both the AME and DME signals not only facilitates their use in telemetering, but also makes it convenient to combine the two for a further saving in electronic hardware. Thus, the return signal from a DME transponder may be directly used for AME measurement. And pulses in either signal can be used to multiplex either ground or airborne equipment to reduce complexity and at the same time increase the variety of functions that can be accomplished.

When, for example, a number of DME's are used in a triangular system, such as that now being installed

Keep on Rolling Along



Units of the 5000-mile range Snark guided missile are shown for the first time on the production line at the Northrop Aircraft plant. The missile will be used by the AF Strategic Air Command.

off Cape Canaveral, a single air-borne transponder may be time-shared among the DME's within range. Present plan is to activate four DME's at a time (the fourth provides redundant data, but is useful in analyzing the results) and sample them at a multiplexing rate of 40 measurements per sec, with a velocity memory in each servo-mechanism smoothing out the data.

An even more promising application of multiplexing is found in a system now being designed for the Eglin range. Two AME's and a DME (similar to the Eleuthera Island installation) will be multiplexed to provide information on up to three separate flight paths. A typical application of this equipment will be the coincidental tracking of a drone, air-to-air missile and an attacking aircraft. The equipment will display nine sets of data, two direction angles and one distance measurement for each of the five tracks. The result will be near-miss information never before available by any means.

An important feature of the continuous-wave tracking systems is that they are all built out of just two basic units, the AME and DME. This simplifies training, maintenance, stocking of spare parts, and a host of other missile-range problems. And yet, a wide variety of tracking devices can be built out of these two basic units. ELSSE, for example, is only a beginning on the use of AME's for range safety instrumentation. Two AME-COTAR's together could supply information that would fit easily into an analog computer network to plot the impact point of the missile if at any moment it were put on a ballistic trajectory. The safety officer could use this information to cut off the motor of an errant rocket with full knowledge that its present course would take it into safe territory.

The AME and DME units are capable, therefore, of providing an almost endless variety of missile-tracking functions. They have short-range accuracy for measuring near-misses between air vehicles in terms of feet and inches, while the same basic equipment can and will be used at the far end of the 5000-mile range that will test the mightiest missiles the U. S. can produce.

Reliability Stressed

The Air Materiel Command plans to recruit 31 civilian engineers for reliability work in ballistic missiles plants and test facilities. Ten AF officers with engineering degrees will be enlisted for quality control assignments. Starting salary for the civilian position is $10,065.

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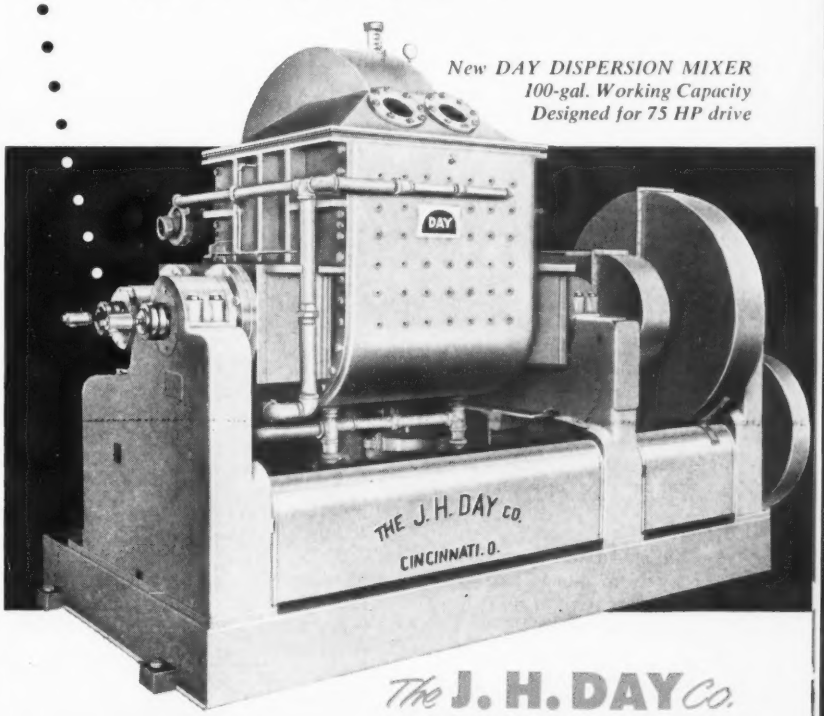

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Dual-Thrust Engines

(CONTINUED FROM PAGE 28)

shown on page 28. In the first, or *tandem-chamber,* configuration, the booster and sustainer grains fire together during the booster phase. The operating pressure in both chambers is high during the booster phase, producing the high booster thrust. Upon depletion of the booster grain, usually made of a propellant with a high burning rate, the sustainer grain continues to burn. This grain burns more slowly, at a lower pressure and for a longer period of time, producing the low-thrust sustainer phase. The engine exhausts to the atmosphere through the booster nozzle during both phases. The pressure in the booster chamber actually determines the thrust during both phases.

The photo on page 27 shows an early tandem-chamber experimental engine.

The second configuration involves the use of one or two propellants in a *single chamber.* As in the tandem-chamber configuration, a single nozzle is employed. Thus the difference in thrust between booster and sustainer phases is achieved by successively producing a high and a low chamber pressure. The propellant charge necessary to produce this pressure "program" can be designed in any number of ways, depending on the relative thrusts and durations required for the two phases.

Dual-thrust engines have been built and successfully fired, employing one "free-standing" grain of a high burning rate for the booster and another free-standing grain of a low burning rate for the sustainer. (A free-standing grain is one which is manufactured separately from the engine chamber and "cartridge-loaded" into the chamber upon final assembly of the engine. It is mechanically supported in the chamber by means of resilient spacers, springs, or other structural devices.) Since free-standing grains do not provide the high loading density required for most present-day applications, the trend is toward the development of dual-thrust, single-chamber engines employing internal-burning, case-bonded grains.

In one engine, currently in the final phases of development at Aerojet, the dual-thrust program is achieved by the design of a grain made of one propellant. In two other Aerojet rockets under development, one propellant is cast concentrically into the other. These engines are discussed in greater detail below.

The third, or *partitioned-chamber,* configuration has a forward and after compartment for the sustainer and booster grains, respectively. The sustainer compartment exhausts through an extension tube which terminates in a small nozzle mounted in the larger booster nozzle. Each of the compartments operates as a completely separate entity, having its own igniter and internal ballistics. Thus each phase is free to operate under optimum conditions. A photo of an early experimental partitioned-chamber, dual-thrust engine after firing is shown on page 28.

The tandem-chamber and single-chamber engines both exhaust through the booster nozzle. Both depend on pressure in the booster chamber to produce both booster and sustainer thrusts. Considering the propellant ballistics and operating conditions to be equal, the only difference between the two, from the standpoint of performance, is the additional weight of the aft closure of the sustainer chamber and the forward closure of the booster chamber, required on the tandem-chamber design. The single-chamber engine can always be made to possess a superior ratio of total impulse to total weight.

As a rule, it is more difficult to manufacture the inert compounds for an engine of the tandem-chamber configuration. The only consideration in favor of the tandem-chamber engine design is the somewhat greater freedom afforded in selection of booster and sustainer propellants and grain configurations because of the semi-independence of the booster and sustainer phases.

Comparison of Chambers

The comparison between the single-chamber and partitioned-chamber configurations is much more subtle. With the partitioned-chamber engine, it is possible to operate both the booster and sustainer grains under optimum conditions, thus obtaining the highest efficiency from each and assuring lower propellant weight. It is conceivable that this will result in operation of the sustainer at a lower pressure than the booster, in which case the weight of the sustainer section of the chamber can be reduced by reducing its wall thickness. No insulation of the booster chamber is required for protection during sustainer operation.

However, the partitioned-chamber engine must carry the additional weight of the center partition and the sustainer nozzle extension tube and

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DC-34 & DC-36 ASSEMBLY FEATURES

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Special contact materials are available for switching in the low level or "dry circuit" range. Excellent reliability can be obtained in this application.

DC-34 & DC-36 DESIGN FEATURES

The motor assembly features a very tightly closed magnetic circuit, which results in low magnetic leakage and high magnetic efficiency since the entire field is concentrated in the useful area. Properly annealed armco is used to provide high permeability and freedom from residual magnetism.

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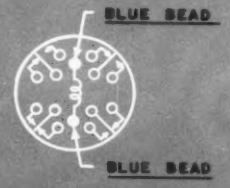
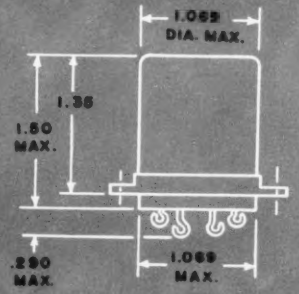
Perforated for easy tear-out.

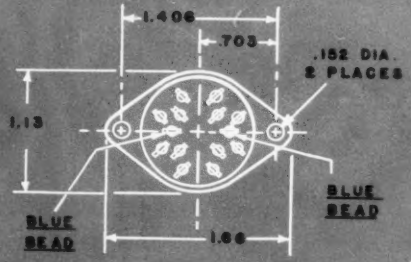
SERIES 34 & 36 SUB-MINIATURE RELAY AND SUB-ASSEMBLIES



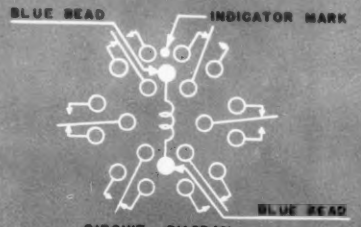
CIRCUIT DIAGRAM
UNENERGIZED BOTTOM VIEW



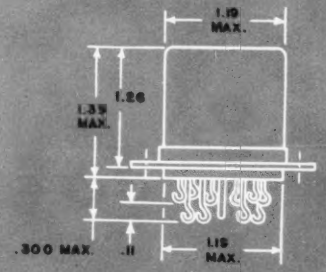
FLANGE POSITION OPTIONAL



DC-34	CHARACTERISTICS	DC-36
4PDT-(4 Form C)	**Contact Form**	6PDT-(6 Form C)
up to 300v. D.C.	**Coil Voltage**	up to 300v. D.C.
up to 22,500 ohms.	**Coil Resistance**	up to 27,500 ohms.
50G, 11ms.	**Shock (operating)**	50G, 11ms.
30G to 500c.p.s. 20G to 2,000c.p.s.	**Vibration (operating)**	30G to 500c.p.s. 20G to 2,000c.p.s.
–65°C to 125°C	**Temperature Range**	–65°C to 125°C
3.25 oz.	**Weight**	4 oz.
MIL-R-25018	**Specifications**	MIL-R-25018
Solder or Plug-in	**Terminals**	Solder or Plug-in
	DETAIL SPECIFICATIONS	
32	**Max. Operating Voltage**	32
26.5	**Nominal Coil Voltage**	26.5
18v. Max.	**Pick-up Voltage @125°C**	18v .Max.
13v. Max.	**Drop-out Voltage @125°C**	13v. Max.
240 ohms. Min.	**Coil Resistance @25°C**	200 ohms. Min.
Silver	**Contact Material**	Silver
2 amps.	**Contact Rating, Resistive**	2 amps.
100,000	**Minimum Operating Life**	100,000
Continuous	**Rated Duty**	Continuous
9ms.	**Operate Time**	9ms.
3ms.	**Release Time**	3ms.
.05 ohms Max.	**Contact Resistance**	.05 ohms Max.
1,000 Meg. Min.	**Insulation Resistance**	1,000 Meg. Min.
1,000 RMS	**Voltage Insulation**	1,000 RMS



CIRCUIT DIAGRAM
UNENERGIZED BOTTOM VIEW



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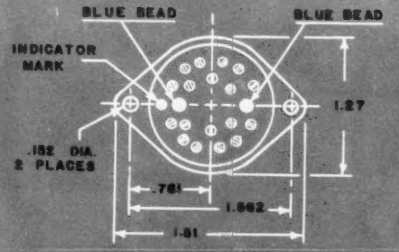

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its attendant insulation and support members. Depending on the size of the engine and the thrust and duration ratios required, weight savings of partitioned-chamber over single-chamber configuration can sometimes be made to offset weight penalties. In this event, the remaining advantages of the single-chamber configuration lie in its design and manufacturing simplicity, and its low CG shift during burning. These advantages, however, are significant.

It is possible to accommodate the largest volume of propellant in the chamber if the propellant charge burns only on its internal perforation and is bonded to or rests snugly against the chamber on its outer (nonburning) surface. For these reasons, the three dual-thrust engines previously referred to are single-chamber engines with internal-burning, case-bonded propellant charges.

Types of Grains Used

Unit 1 achieved the dual-thrust characteristic by proper design of the perforation of a grain consisting of only one propellant, as shown in the drawing on page 28. Initially, the projecting lands at the aft section of the grain provide a large burning area. The high initial burning area causes the propellant to burn at a high pressure, because the chamber pressure varies directly with the ratio of propellant burning area to nozzle throat area.

The transition from the booster to the sustainer phase occurs when the lands are consumed. At this point, the burning area reduces abruptly to the value required to produce the lower (sustainer) chamber pressure.

Dual-thrust engine designs in which it is possible to obtain the desired performance with one propellant are limited, and design of the grain is sometimes extremely difficult, because the booster grain is, in effect, "carved" out of the center portion of the charge. When it is impossible or impracticable to use one propellant, two propellants must be employed, as in Units 2 and 3.

For both Units 2 and 3, concentric case-bonded grains are used because: (1) They provide the greatest loading density possible; (2) no inert members are required for support of the propellant in the chamber; and (3) the chamber wall is protected against heat by the propellant itself.

A sketch representing the grain design of Units 2 and 3 will be found on page 28. The layer of propellant adjacent to the chamber wall is the sustainer propellant, and the inner propellant is the booster grain. The propellants belong to the same family of formulations, but the burning rate of the booster is considerably higher than that of the sustainer.

The internal perforation is designed and nozzle throat diameter set so that the initial ratio of propellant burning area to nozzle throat area will produce the required high chamber pressure for the boost phase.

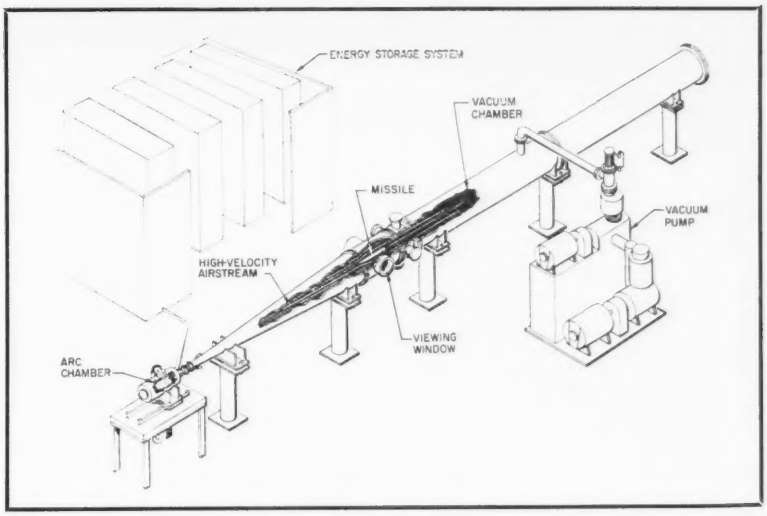
For a given ratio of burning area to nozzle throat area, a propellant possessing a high burning rate will produce a higher chamber pressure than one which has a low burning rate. Conveniently, then, the internal perforation of a concentric-propellant, dual-thrust grain can be designed so that the burning area does not change abruptly during the transition from booster to sustainer. As the flame front progresses radially outward through the fast-burning booster propellant, it forms a pattern which will produce the correct transition to the sustainer phase when it enters the slower-burning sustainer propellant.

It may be seen that, whereas in the design of a single-propellant dual-thrust grain, the burning rate and the slope of the burning rate curve are essential parameters, the geometric design of a two-propellant system is independent of the slope of the burning rate curves of each propellant, and is dependent totally on the burning rate of each propellant at the design pressure levels of the booster and sustainer phases, respectively.

The web thickness of each section of the charge is dependent on the burning rate of each propellant and the required duration of each phase.

Since the same nozzle is used for both the booster and sustainer phases, its throat area must be selected to produce the proper thrust for each phase and the proper area ratio for each operating pressure required. The expansion ratio (ratio of nozzle exit area to throat area) can be optimized for one specific flight condition or it can establish a compromise. For surface-to-air applications, the nozzle can be designed to produce optimum expansion during the sustainer phase of flight, and at a specifically chosen altitude. When the engine is statically fired at sea level, the nozzle will produce near-optimum expansion of the booster exhaust gases, but considerable overexpansion of the sustainer gases. The static sea level sustainer performance, therefore, is much less than optimum. In actual flight, greater efficiency is realized in the sustainer phase because of the higher ratio of chamber pressure to atmospheric pressure.

Within the limits of practicability, solid rocket engines, no matter how large or small, can be made to produce a variety of thrust programs. The dual-thrust program is a sample of how a single engine can be tailor-made to fit a missile system simply, reliably and economically.



Fastest and Hottest Commercial Wind Tunnel

Speeds up to 15,000 mph and temperatures 6000 deg hotter than the sun's surface will be reproduced in this 44-ft-long wind tunnel being built at Lockheed's missile research laboratory, Palo Alto, Calif. It will be used to speed development of the Polaris ballistic missile. Gas in arc chamber heats instantly to 18,000 F, explodes through tunnel and blasts against missile's nose.

ARS news

9 ARS Technical Sessions Set for Dallas Meeting

NINE ARS technical sessions, 13 ASME technical sessions, addresses by four outstanding speakers and three field trips highlight the program for the Joint ASME-ARS Aviation Conference, to be held at the Statler-Hilton Hotel in Dallas, Tex., March 17–20.

Of special interest in the ARS portion of the program are sessions on nuclear propulsion and aerodynamic propulsion; a guided missile instrumentation panel; and a forum on lunar colonization. Other technical sessions will be devoted to solid rockets, rocket installations, new materials and processes, target drones and space flight.

A number of the ASME sessions will also be of interest to ARS members. Among these are sessions on the thermal thicket in the laboratory, human factors in engineering, and data acquisition and processing.

The three luncheons at the meeting will be addressed by Gen. Thomas D. White, Air Force Chief of Staff; Rear Adm. Rawson Bennett, Chief of Naval Research; and Lt. Gen. Samuel E. Anderson, Commander, Air Force Air Research and Development Command.

Those attending the meeting will have a choice of three field trips on Thursday, March 20. They can visit the headquarters of Astrodyne, Inc., at McGregor, Tex.; Chance Vought Aircraft in Dallas and Convair's Ft. Worth plant; and Texas Instruments, Southwest Airmotive and other facilities at Love Field.

The complete program for the meeting, including ARS preprint numbers for all papers, follows:

SUNDAY, MARCH 16

3:00 p.m. **Mezzanine Floor**

Registration Opens

MONDAY, MARCH 17

9:30 a.m. **Embassy East**

Solid Rockets

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: William Schaafsma, Director of Engineering, Grand Central Rocket Co., Redlands, Calif.

Vice-Chairman: E. F. Fiock, Astrodyne, Inc., McGregor, Tex.

★ Propellant Explosives Classification and the Effect on Field Handling of Missiles, by W. F. Haite, Thiokol Chemical Corp., Huntsville, Ala. (576-58)

★ Comparison of Dual-Thrust Motors with Separate Booster and Sustainer Motors as Solid-Propellant Propulsive Systems for Guided Missiles, by George E. Miles, Astrodyne, Inc., McGregor, Tex. (577-58)

★ Stability of Rubber-base, Ammonium Nitrate Propellants, by M. H. Whitlock and J. A. Keller, Phillips Petroleum Co., Bartlesville, Okla. (578-58)

★ Solid Propellant Engine Selection Studies for Ballistic Missiles, by J. L. Gallagher and T. E. Phillips, Convair, A Division of General Dynamics Corp., Fort Worth, Tex. (579-58)

9:30 a.m. **Gold Room**

Air Transport—I

Local Airlines and Equipment

Auspices of ASME Aviation Division

9:30 a.m. **Embassy West**

Challenges of High Speed Flight—I

Aircraft Mechanisms

Auspices of ASME Aviation Division

12:00 Noon **Grand Ballroom**

Welcoming Luncheon

Presiding: John M. Stevenson, chairman, North Texas Section, ASME; Delhi-Taylor Oil Corp., Dallas.

Speaker: Gen. Thomas D. White, USAF, Air Force Chief of Staff, Washington, D. C.

2:30 p.m. **Embassy East**

Rocket Installations

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: R. F. Rose, Chief, Propulsion Dev. Section, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.

Vice-Chairman: H. W. Graham, Propulsion Project Engineer, Chance Vought Aircraft, Inc., Dallas, Tex.

★ How Lockheed Achieved High Performance with the All-Solid X-17 Vehicle, by James Marmor, Lockheed Aircraft Corp., Sunnyvale, Calif. (580-58)

★ Installation of Solid Rocket Engines, by Gene Dolgonas, Aerojet-General Corp., Sacramento, Calif. (581-58)

★ Design of Flame Deflectors, by Rollo

ARS Program Chairman

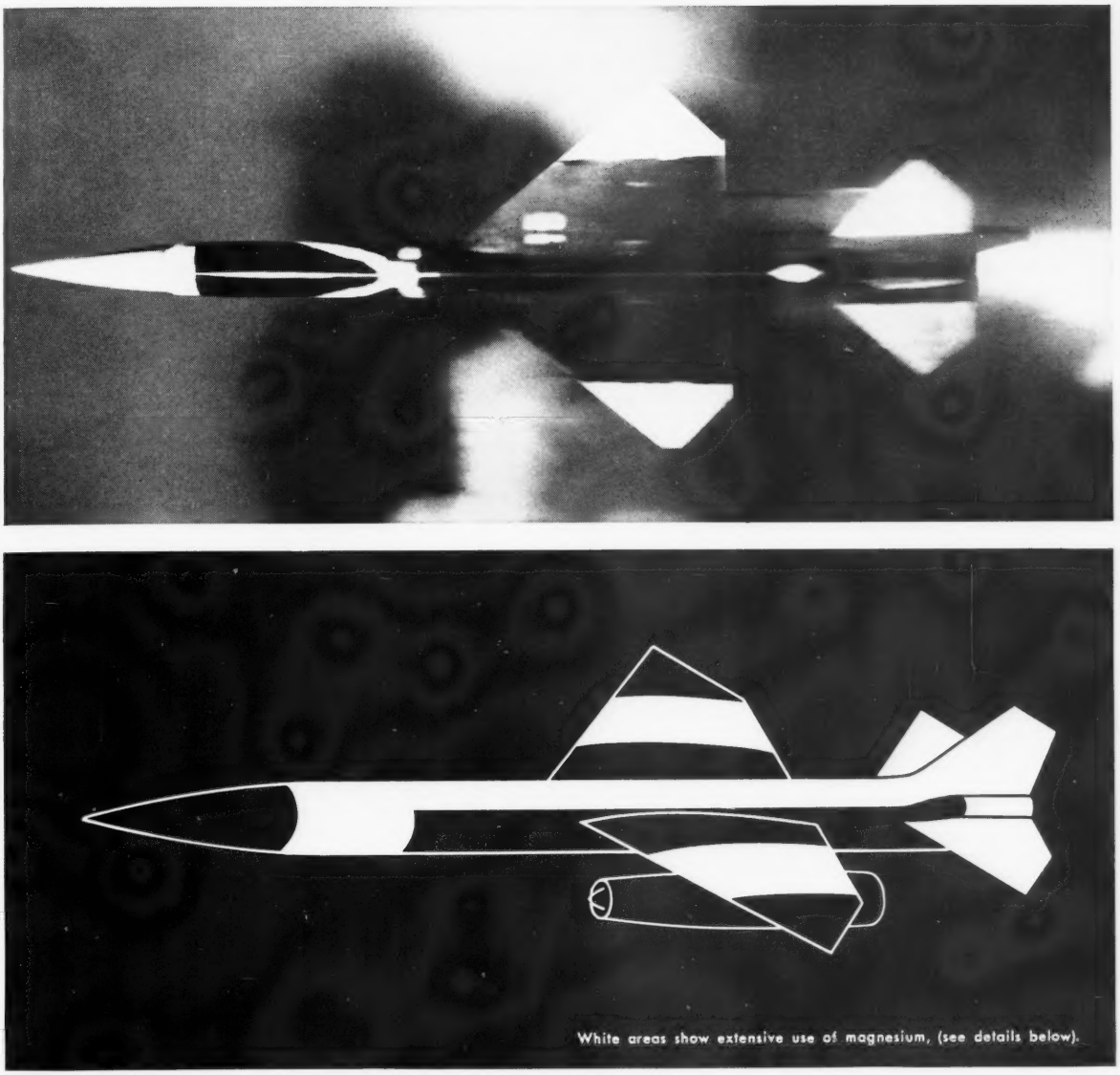
George Craig

Featured Speakers at Dallas Meeting

Rear Adm. Rawson T. Bennett

Lt. Gen. Samuel E. Anderson

Gen. Thomas D. White



HOW ELEVATED-TEMPERATURE MAGNESIUM ALLOYS HELP BOMARC KEEP FIGHTING WEIGHT

Approximately 230 lbs. of magnesium is used in the airframe of the Bomarc, powerful surface-to-air missile. And for good reason: In each case, the specific application called for light weight and retention of strength, rigidity and other properties at elevated temperatures. The logical choice was sheet, extrusions or castings of elevated-temperature magnesium alloys.

EXAMPLES:

BODY. The body skin and doors of both nose and aft sections utilize 103 lbs. of HK31A sheet and castings. Resultant weight savings were 23 lbs., including a net reduction of 6 lbs. by using a magnesium casting for a door frame structure.

WING, FIN AND TAIL. 111 lbs. of HK31A sheet were used in the wing, elevators and elevator stubs, fin and rudder. All leading and trailing edges of control surfaces for wings and fin are HM31XA extrusions. Here another 8 lbs. were saved by using an elevated-temperature magnesium alloy.

These are but a few instances of how precious weight was saved in the Bomarc. For more information about the use of magnesium alloys in aircraft, rockets and missiles, contact the nearest Dow sales office or write directly to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1407H.

YOU CAN DEPEND ON DOW

AMERICAN ROCKET SOCIETY

500 Fifth Ave., N. Y. 36, N. Y. Pennsylvania 6-6845

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Krafft A. Ehricke, Space Flight

S. Pickford, Aerojet-General Corp., Azusa, Calif. (582-58)

★ Application of Rocket Engines to American Aircraft, by James M. Cumming, Rocketdyne, A Division of North American Aviation, Inc., Canoga Park, Calif. (583-58)

2:30 p.m. Gold Room

Air Transport—II

Local Airlines Operations and Maintenance

Auspices of ASME Aviation Division

2:30 p.m. Embassy West

Challenges of High Speed Flight—II

Mechanisms and Developments

Auspices of ASME Aviation Division

6:00 p.m. Engineers Club of Dallas

Cocktail Party

TUESDAY, MARCH 18

9:30 a.m. Embassy East

Guided Missile Instrumentation Panel

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: Robert E. Luke, Ramo-Wooldridge Corp., Los Angeles, Calif.

★ Computing and Calibrating Vibration Power Spectra, by George M. Barr and John Sorrels, Ramo-Wooldridge Corp., Los Angeles, Calif. (584-58)

★ Cures for Which There Are No Diseases, by Martin L. Klein, Cohu Electronics, San Diego, Calif. (585-58)

★ Standardization—Pro and Con, by Max A. Lowy, Ramo-Wooldridge Corp., Los Angeles, Calif. (586-58)

★ Television Applied to Instrumentation, by John P. Day, Kin Tel, San Diego, Calif. (587-58)

9:30 a.m. Silver Room

Air Transport—III

Maintenance by the Major Airlines

Auspices of ASME Aviation Division

9:30 a.m. Embassy West

The Thermal Thicket in the Laboratory—I

Hydraulics and Accessories

Auspices of ASME Aviation Division

9:30 a.m. Gold Room

Human Factors in Engineering—1

Auspices of Human Engineering Committee of ASME Aviation Division, Human Factors in Engineering Committee of the Management Division and Human Factors Society of America

12:00 Noon Grand Ballroom

Luncheon

Toastmaster: G. H. Craig, general co-chairman, ASME-ARS Conference; past-president, North Texas Section, ARS; Convair, Fort Worth.

Response: George P. Sutton, president, AMERICAN ROCKET SOCIETY; Chief Preliminary Design, Rocketdyne, Canoga Park, Calif.

Speaker: Rear Adm. Rawson Bennett, Chief of Naval Research.

2:30 p.m. Junior Ballroom

Lunar Colonization: Its Challenges

Auspices of the AMERICAN ROCKET SOCIETY

Moderator: Major David G. Simons, Air Force Missile Development Center, Holloman AFB, N. M.

Forum

Arnold Small, Convair, A Division of General Dynamics Corp., San Diego, Calif.

Irwin Cooper, The Rand Corp., Santa Monica, Calif.

Eugene Konecci, Douglas Aircraft Co., Inc., Tulsa, Okla.

Franki L. Van Der Wal, Ramo-Wooldridge Corp., Los Angeles, Calif.

Julian Ward, School of Aviation Medicine, Randolph AFB, Tex.

Clyde Tombaugh, New Mexico College of A & MA, State College, N. M.

2:30 p.m. Gold Room

The Thermal Thicket in the Laboratory—II

Bearings and Lubrication

Auspices of ASME Lubrication Division

2:30 p.m. Silver Room

Air Transport—IV

Passenger Comfort—Civilian and Military

Auspices of ASME Aviation Division

2:30 p.m. Embassy East

New Materials and Processes

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: S. O. Perry, Chief Engineer, Missiles, Chance Vought Aircraft, Inc., Dallas.

Vice-Chairman: C. F. Crabtree, Power Plant Group Engineer, Convair, Fort Worth.

★ Ceramic Coatings of Engines, by Paul Huppert, Gulton Industries, Inc., Metuchen, N. J. (588-58)

★ Reinforced Plastics (RPD) for Rockets and Missiles, by D. V. Rosato, Raybestos-Manhattan, Inc., Manheim, Pa. (589-58)

★ Recent Advances in Plastic Materials for Rocket and Missile Construction, by George Epstein and R. J. Brown Jr., Aerojet-General Corp., Azusa, Calif. (590-58)

6:00 p.m. Junior Ballroom

Social Hour

7:00 p.m. Grand Ballroom

Banquet

Toastmaster: J. E. Jonsson, president, Dallas Chamber of Commerce;

president, Texas Instruments, Inc., Dallas.

Speaker: To be announced.

WEDNESDAY, MARCH 19

9:30 a.m. Junior Ballroom

Drones

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: James F. Reagan, Ramo-Wooldridge Corp., Los Angeles, Calif.

Vice-Chairman: B. O. Robinson, Temco Aircraft Corp., Dallas.

★ Eight Minute Duration Solid Propellant Engine for XKDT-1 Target Drone, by J. A. Crask, Astrodyne, Inc., McGregor, Tex. (596-58)

★ A Review of the Scoring Problem, by C. R. Bonnell, Beech Aircraft Corp., Wichita, Kan. (597-58)

★ Combat Surveillance Systems, by Kirby Lamar, Army Electronics Proving Grounds, Fort Huachuca, Ariz. (598-58)

★ Advances in Rocket Propulsion Systems for Target Aircraft, by Arthur Sherman, Reaction Motors, Inc., Denville, N. J. (599-58)

★ Radar and Infra-Red Simulation Techniques, by A. W. McMurtrey, Temco Aircraft Corp., Dallas, Tex. (600-58)

★ The Role and Function of Target Systems in the Weapon System Concept, by Philip G. Blenkush and Abraham Fiul, Radioplane Co., Van Nuys, Calif. (601-58)

★ Liquid Propellant Rocket Engines for Drone Applications, by Herbert H. Isaacs, Rocketdyne, Canoga Park, Calif. (608-58)

9:30 a.m. Embassy East

Nuclear Propulsion

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: R. L. Lemmon, Project Engineer, Convair, Fort Worth, Tex.

★ Dynamic Analysis of a Nuclear Rocket Engine System, by B. Ross Felix, R. J. Bohl and R. Matulenko, Rocketdyne, A Division of North American Aviation, Inc., Canoga Park, Calif. (593-58)

★ A Development Approach for Nuclear Rocket Engines, by Brent N. Smith and Tom F. McGrath, Rocketdyne, A Division of North American Aviation, Inc., Canoga Park, Calif. (594-58)

★ Performance Calculations for Hybrid Nuclear-Chemical Rocket Propulsion Systems, by Leon Green Jr., Aerojet-General Corp., Azusa, Calif., and James M. Carter, Carter Laboratories, Pasadena, Calif. (595-58)

★ Some Data and Comments Concerning the Working Fluid Nuclear Rocket, by Lester M. Bagnall, Convair, A Division of General Dynamics Corp., Fort Worth, Tex. (592-58)

★ Comparison of Nuclear and Chemically Powered Rockets, by L. S. Shenfil, H. S. McQueen and I. G. Henry, Aerojet-General Corp., Azusa, Calif. (607-58)

9:30 a.m. Gold Room

The Thermal Thicket in the Laboratory—III

Elevated Temperature Test Facilities

Auspices of ASME Heat Transfer Division

on the calendar

1958

March 2–6	International Gas Turbine Conference and Exhibit, ASME, Hotel Shoreham, Washington, D.C.
March 6, 13	Gas Dynamics Colloquium, Technological Institute, Northwestern U., Evanston, Ill.
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**
March 17–21	Fourth Nuclear Engineering and Science Conference of the 1958 Nuclear Congress, Chicago International Amphitheatre, Ill.
March 17–21	14th Annual Conference of National Association of Corrosion Engineers, Civic Auditorium, San Francisco.
March 18–19	Conference on Extremely High Temperatures, AF Cambridge Research Center, Bedford, Mass.
March 18–19	Inter-Service and Industry Symposium on Guided Missile Training Equipment, Naval Ordnance Lab., White Oak, Silver Spring, Md.
March 24–26	Annual Aero Medical Assn. Meeting, Statler Hotel, Washington, D.C.
March 24–27	IRE National Convention, NYC.
April 3, 10, 17, 24	Gas Dynamics Colloquium, Technological Institute, Northwestern U., Evanston, Ill.
April 22–24	1958 Electronic Components Conference, sponsored by IRE, AIEE, EIA, Ambassador Hotel, Los Angeles.
April 27–May 1	60th Annual Meeting of American Ceramic Society, Penn-Sheraton Hotel, Pittsburgh, Pa.
April 28–30	Second Annual AFOSR Astronautics Symposium, Denver, Colo.
May 4–7	Fourth National Instrumentation Flight Test Symposium of ISA, Park Sheraton Hotel, NYC.
June 2–4	**National Telemetering Conference under auspices of ARS, IAS, AIEE, ISA, Lord Baltimore Hotel, Baltimore, Md.**
June 8–12	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
June 16–18	Second National Convention on Military Electronics, sponsored by IRE, Sheraton Park Hotel, Washington, D. C.
June 19–21	**Heat Transfer and Fluid Mechanics Institute Meeting, University of California, Berkeley.**
July 6–12	Second Annual Engineering Seminar in R&D Management Development, Pennsylvania State University.
Aug. 24–30	**Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.**
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 22–24	IRE National Symposium on Telemetering, the American Hotel, Bal Harbour, Miami Beach, Fla.
Sept. 24–25	National Electronics Conference, sponsored by IRE, AIE, EIA, Hotel Sherman, Chicago.
Sept. 29–30	Basic Science Div., American Ceramic Society, Wright-Patterson AFB, Dayton, Ohio.
Nov. 10–13	AF School of Aviation Medicine-Southwest Research Institute Space Flight Symposium, San Antonio, Tex.
Nov. 16–21	**ARS 13th Annual Meeting, Hotel Statler, New York, N. Y.**

9:30 a.m. Embassy West

Data Acquisition and Processing—I

Auspices of ASME Instruments and Regulators Division

12:00 Noon Grand Ballroom

Luncheon

Toastmaster: Maj. Gen. C. F. Born (USAF-Ret.), Texas Instruments, Inc., Dallas.

Speaker: Lt. Gen. S. E. Anderson, USAF, Commander, Air Research and Development Command, Baltimore, Md.

2:30 p.m. **Junior Ballroom**

Space Flight

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: A. Kalitinsky, Convair, Fort Worth.

Vice-Chairman: C. L. Seacord, Convair, Fort Worth.

★ The Mechanics of Some Interspace Orbits, by W. A. Orr, Convair, Fort Worth, Tex. (603-58)

★ Optimum Thrust Programming Along Arbitrarily Inclined Rectilinear Paths, by Angelo Miele, Purdue University. W. Lafayette, Ind. (604-58)

★ Flight Mechanics of Low Thrust High Energy Space Vehicles, by F. Ferebee, Rocketdyne, A Division of North American Aviation, Inc., Canoga Park, Calif. (605-58)

★ Re-entry Structures, Thermal Stresses and Limit Design, by D. N. Buell, Chrysler Corp., Detroit, Mich. (606-58)

2:30 p.m. **Embassy East**

Aerodynamic Propulsion

Auspices of the AMERICAN ROCKET SOCIETY

Chairman: Weldon Worth, Consultant to Chief, Power Plant Lab., Wright ADC, Dayton, Ohio.

Vice-Chairman: W. C. Schoolfield, Asst. Chief Engineer, Missiles, Chance Vought Aircraft, Inc., Dallas.

★ High Speed Propulsion Schemes: An Analytical Comparison, by Andrew Charwat, Assoc. Professor, University of California, Los Angeles. (602-58)

(Invited spokesmen from both the propulsion and missile design fields will present prepared discussions at conclusion of presentation.)

2:30 p.m. **Gold Room**

The Thermal Thicket in the Laboratory—IV

Elevated Temperature Test Facilities

Auspices of ASME Heat Transfer Division

2:30 p.m. **Embassy West**

Data Acquisition and Processing—II

Auspices of ASME Instruments and Regulators Division

THURSDAY, MARCH 20

9:00 a.m. **Field Trips**

Trip No. 1—Astrodyne, Inc., McGregor, Tex.

Trip No. 2—Chance Vought Aircraft, Inc., Dallas, and Convair, Fort Worth.

Trip No. 3—Texas Instruments, Inc., Southwest Airmotive and other Love Field facilities.

IAF Meeting to Be Held In Amsterdam Aug. 24-30

The Ninth Annual Congress of the International Astronautical Federation will be held in Amsterdam, The Netherlands, Aug. 24–30. Registration and hotel accommodation forms for the meeting may be obtained by writing to the Secretariat of the Congress, Mrs. A. F. P. Volten, Molenstraat, The Hague, Netherlands. Closing data for registration and hotel reservations is March 31.

Committee Chairmen Named

The full slate of ARS committee chairmen for 1958 named by President George P. Sutton is as follows:

Awards, Kurt Stehling; Policy, Martin Summerfield; Finance, S. K. Hoffman; Program, Howard Seifert; Publications, Simon Ramo; and Membership, H. W. Ritchey. Charles H. King Jr., United Aircraft Corp., has been named ARS representative on the ASME-ARS Joint Committee.

Joins Astronautics Staff

John A. Newbauer has joined the staff of ASTRONAUTICS as Associate Editor. A graduate of the University of California at Berkeley, he had visited the Michelson Laboratory at the U. S. Naval Ordnance Test Station (NOTS), China Lake, Calif., while studying chemistry, and later joined NOTS as a technical writer and editor for the Rocket Dept.

During almost six years at NOTS, he was closely involved with such projects as development of the 2.75-in. folding fin aircraft rocket, the 5-in. Zuni, the LAR liquid propellant propulsion system, and various other experimental missile and ordance projects.

His duties on ASTRONAUTICS will include coverage of important developments in the field of missile electronics.

SECTION NOTES

Alabama: The annual dinner meeting of the Alabama Section was held in December in Huntsville at the Shalamar Club. Guest speaker was Comdr. Robert C. Truax, immediate past-president of ARS. A full crowd, including wives and guests of members, was served a holiday meal.

Comdr. Truax was introduced by Wernher von Braun, who noted that the commander was a Navy man, working for the Air Force and speaking to an Army group—a notable example of interservice cooperation.

Slides and color movies were used by Comdr. Truax to illustrate his talk on early rocket experiments by the Navy. His experiments began while he was at the Naval Academy. Later he directed development of JATO and the Lark missile. The address included some comments on the work of Robert H. Goddard.

New officers of the Section were introduced by Cliff Fitton, outgoing president. They are: David H. Newby, president, and Rodney D. Stewart, vice-president. Newby is chief of the test and evaluation branch, Rocket Development Laboratories, Redstone Arsenal. Stewart is assistant to the technical director, Redstone Div., Thiokol Chemical Co.

Other guests at the meeting included Maj. Gen. H. N. Toftoy, commanding general, Redstone Arsenal; Col. Matthew R. Collins Jr., director, Redstone Anti-Missile Missiles Service Office; Hermann Oberth; Martin Schilling; and M. L. Rankin.

At the January board meeting, considerable attention was given to the problem of teen-age rocket experiments. It is hoped that the Section will be able to encourage interest in rocketry while impressing upon the public the dangers inherent in any actual tests. In particular, a large group of high school students in Decatur, Ala., has shown an interest in forming a rocket club.

A presentation of "Physics of a Nuclear Powered Ion Space Vehicle" by A. C. Menium of North Carolina State College was sponsored by the Section on Jan. 20. A large crowd enjoyed coffee and doughnuts after the meeting.

At the February meeting, Dieter Huzel of North American Aviation gave a classified lecture on large liquid rocket motors.

A meeting on guidance is tentatively scheduled for March 19.

A brief newsletter is being published by the Section, with Glen Deuel as editor. It is sent to Section members to keep them informed of meetings and activities.

—Charles T. Paludan

Columbus: An 8-in. snowfall which prevented a number of members, as well as the scheduled guest speaker, Herbert Broida of the National Bureau of Standards, from attending the December meeting, failed to dampen the spirits of those who did manage to attend. The group heard an address by Rudolph Edse of the Aeronautical Engineering Dept. of Ohio State University on "Design of Supersonic Expansion Nozzles and Re-entry Problems." A question-and-answer period followed Dr. Edse's talk.

Florida: Col. L. M. Orman, director of Army tests at AFMTC and newly elected vice-president of the Section, was the guest speaker at the January meeting. Col. Orman showed a film on "Troop Handling of the Redstone Missile," and offered additional comments on the subject in his talk at the well-attended meeting.

Holloman: William A. Fowler, professor of physics at the California Institute of Technology, was the guest speaker at the Section's January meeting. Dr. Fowler's topic, publicized locally as "Origin of the Universe," was concerned somewhat more with the synthesis of elements in the stars and stellar equilibrium.

He explained the Gamow theory of the possibility of a single primeval explosion of a mass of hydrogen as the origin, which in turn could account for the expanding universe. He displayed schematics of the transmutation of hydrogen to helium and of helium to carbon, and related the gravity field of the star to the balance between transmutation and energy radiation. One interesting point was the present estimate that there is something of the order of a billion-billion times as many hydrogen atoms in the universe as all the heavy elements combined.

Dr. Fowler clearly indicated during his lecture the uncertainty of some theories while clearly showing the mechanics of transmutation in those areas where they are known beyond any reasonable doubt.

The lecture was cleverly handled as a descriptive talk in a manner which pleased the nontechnical members of the audience while still retaining enough scientific concepts to interest everyone.

—Lt. Col. Harry L. Gephart

Indiana: Newly elected officers of the Section are Donald Emmons, president; Lou Richards, vice-president; Al Pinchek, secretary; and Joe Fowler, treasurer. All are with the Jet Propulsion Center, Purdue University.

Wayne H. Munyon and Donald Crabtree, former president and vice-president, respectively, of the Section, are moving to California.

At Annual Dinner of Alabama Section

Comdr. Robert C. Truax (extreme right), guest speaker at annual dinner meeting of Alabama Section, is shown at the meeting with (left to right) Dave Newby, newly elected Section President; Maj. Gen. H. N. Toftoy, commanding general, Redstone Arsenal; Cliff Fitton, outgoing Section President; and Hermann Oberth.

New York: Leonard S. Wiener, chief rocket design engineer, Rocket Dept., Curtiss-Wright Corp., has been elected president of the New York Section for 1958. Other officers are Charles J. Marsel, New York University, vice-president; Zola Fox, Reaction Motors, secretary; and Eric W. Harslem, treasurer.

Northeastern New York: Newly elected officers of the Section are T. C. Swartz, president; E. I. Finger, vice-president; W. L. Hancock, secretary; and A. B. Brown, treasurer.

Sacramento: Richard Crandall, missile liaison engineer, Douglas Aircraft Co., Sacramento, was the guest speaker at the December meeting of the Section, attended by 55 members and guests. Crandall described the functions of the local Douglas facility and commented on movies on the Honest John and on the Douglas DC-8 Jetliner shown at the meeting.

Results of the election of 1958 officers were made known at the January dinner meeting, attended by 60 members and guests. Outgoing president Dan Tenenbaum reported that Clair M. Beighley had been elected president for the coming year. Other new officers are Wayne Fenton, vice-president; R. M. Beattie, treasurer; G. S. James, corresponding secretary; and H. J. Archer, recording secretary.

The meeting was also marked by an informative, as well as amusing talk by R. J. (Bob) Mill, manager of the Manufacturing Div., Aerojet Liquid Rocket plant in Sacramento, on "Time Compression in the Manufacture of Rocket Engines." His 10 years of experience with Aerojet allowed him to expound upon the requirements, difficulties, advantages, by-products and even some humorous results of a time-compressed manufacturing program.

—Wayne H. Fenton

Southern California: John F. Tormey, chief of research, Rocketdyne, was the featured speaker at the January meeting of the Section. Dr. Tormey's topic was "Liquid Rocket Propellants: Is There an Energy Limit?" He discussed liquid propellants from a chemical point of view, outlining the present state of rocket propellant chemical science and examining opportunities and ability to increase present specific impulse. In discussing the limits of energy-producing capability of chemical systems in rocket combustion, Dr. Tormey noted that there is a theoretical possibility of a 50 per cent increase in specific impulse over today's propellants.

R. Harvey Anselm

Wichita: New officers of the Wichita Section are R. Harvey Anselm, manager, Missile Engineering Div., Beech Aircraft, president; C. Marvin Long, preliminary design group supervisor, powerplant staff, Boeing, vice-president; Dean E. Bur-

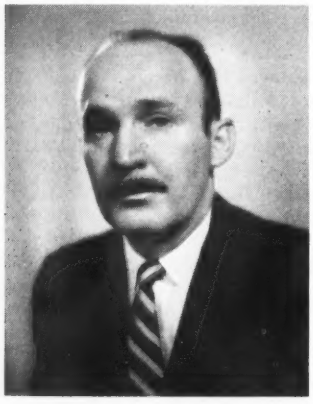
leigh, manager, engineering administration, Beech, treasurer; and William E. Simpkin, assistant professor, aeronautical engineering department, Wichita University, secretary. They will serve through next November.

TECHNICAL DIVISIONS

Space Flight: The Technical and Education Subcommittee of the Space Flight Committee has issued another interim report on its survey of educational opportunities in the space flight field.

TESC questionnaires were sent to 189 colleges and universities and at the time of the report 80 replies had been received. Of this number, 47, or approximately 60 per cent, noted that the school concerned was offering or planned to offer courses in this area, while 29, or about 35 per cent, offered research opportunities in fields related to space flight.

Solid Rocket: Ivan E. Tuhy, staff engineer, solid propellants, The Martin Co., has been named chairman of



Ivan E. Tuhy

the Solid Rocket Committee for 1958. He succeeds William L. Rogers of Aerojet-General in the post. Mr. Tuhy has been with Martin since 1940 and has been in solid propellant work since 1946. An organizer of the ARS Baltimore-Washington Section, he is a past president of the Baltimore Section.

William Schaafsma, director of engineering, Grand Central Rocket Co., has been named vice-chairman of the committee. Other committee members are: Barnet R. Adelman, Ramo-Wooldridge; D. F. Sprenger, Aerojet; Arch C. Scurlock, Atlantic Research Corp.; C. Dana McKinney Jr., Allegany Ballistics Laboratory; Harold W. Ritchey, Thiokol; Emil A. Malick, Phillips Petroleum Co.; and William Fagan, Wright Air Development Center.

Instrumentation and Guidance: Lawrence S. Brown, new chairman of the Instrumentation and Guidance Division, has announced the make-up of his committee.

Vice-chairman is Walter Wrigley, Instrumentation Laboratory, Dept. of Aeronautical Engineering, MIT. Committee members are: Theodore Buchhold, General Electric Co.; Herbert Friedman, Naval Research Laboratory; Myron D. Lockwood, Sperry Gyroscope Div. of Sperry Rand; Max Lowy, Ramo-Wooldridge; Charles J. Mundo, Arma Div., American Bosch Arma; R. J. Parks, Jet Propulsion Laboratory; Robert E. Roberson, Autonetics Div. of North American Aviation; E. King Stodola, Reeves Instrument Corp.; William C. Strang, Convair; and W. H. Thatcher, Bell Telephone Laboratories.

New Florida Section Officers

Newly elected officers of the Florida Section are (left to right) J. F. Thompson, RCA Missile Test Project, AFMTC, treasurer; Capt. R. F. Sellars, director of Navy tests, AFMTC, president; Col. L. M. Orman, director of Army tests, AFMTC, vice-president; and Capt. B. A. Small, Army project officer, AFMTC, secretary.

CORPORATE MEMBERS

Rocketdyne has started construction of the first U.S. facility to service ballistic missile rocket engines. The $1.5-million center will support AF field units of Atlas, Thor and Jupiter. J. A. Broadston will head the organization, which expects to employ 1000 persons by mid-year. L. C. Vetter will be in charge of a 180-member team of overhaul specialists, while G. E. Jarvis and P. P. Callaway will head the field service and logistic support units, respectively.

° ° °

Atlantic Research Corp. will break ground this month for its new, three-wing, 55,000 sq ft headquarters in Fairfax County, Va.

° ° °

Minneapolis-Honeywell Regulator Co. has established a Missile Equipment Div. at Pottstown, Pa., to consolidate its missile activities. The company has acquired a major contract for automatic control systems for missile ground facilities.

° ° °

The Mountain View (Calif.) Labs. of **Sylvania Electric Products, Inc.,** will build a 50,000 sq ft facility to house administrative headquarters, as well as the reconnaissance system lab.

° ° °

American Bosch Arma Corp. has formed a Technical Advisory Committee to study the future needs of the U. S. economy and how ABA can fulfill these needs. The committee is headed by Clifton T. Foss, ABA vice-president, and includes: C. D. Bock, technical director, Missile Guidance Dept.; Paul Savet, technical consultant, R&D Dept.; W. T. Chow, head, Computer Section; J. Statsinger, asst. chief engineer, MGD; and R. L. Bishop, director, research planning.

° ° °

Texas Gas Transmission Co. has signed a letter of intent to acquire an interest in **Grand Central Rocket Co.** via an exchange of stock.

° ° °

Negotiations are under way by **Consolidated Electrodynamics Corp.** with Cenco Instruments Corp., manufacturer and distributor of scientific and laboratory equipment, to combine their companies.

° ° °

The **AiResearch Aviation** Metal Fabricating Dept. has moved into enlarged facilities comprising 15,000 sq ft of working space at the new Culver Industrial Center, Los Angeles. Another structure of 25,000 sq ft is planned for the near future.

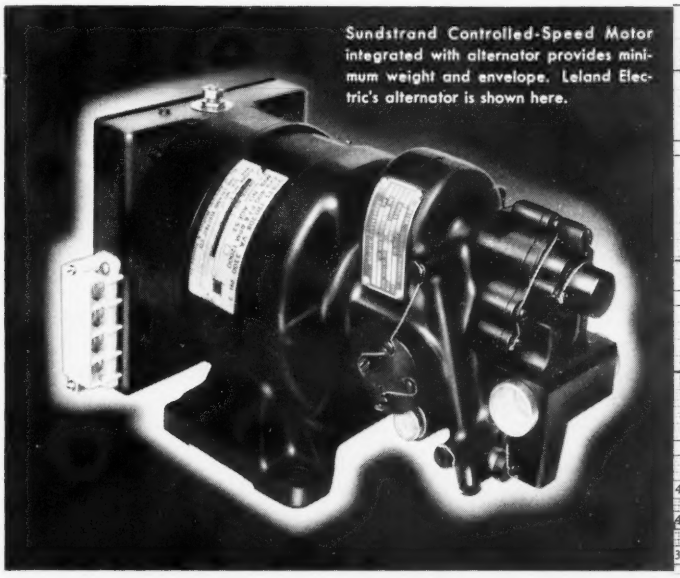
° ° °

Temco Aircraft Corp. has entered into an agreement to acquire 80% of the stock of Fenske, Fedrick & Miller, Inc., a West Coast electronics company, through an exchange of stock.

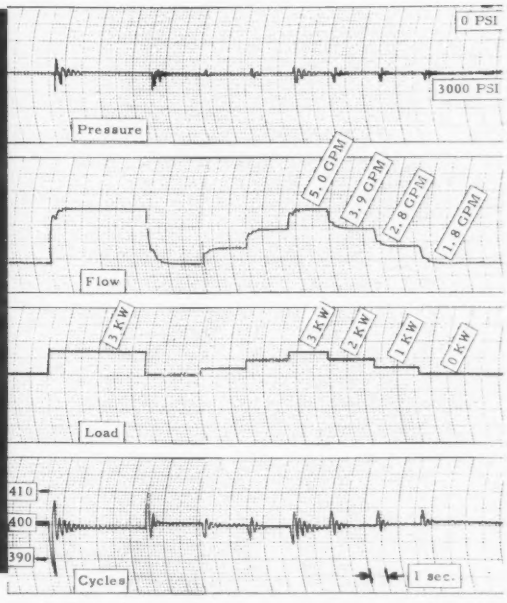
° ° °

The merger of **Norden-Ketay Corp.,** Stamford, Conn., and **Solar Aircraft Co.** has been approved by the boards of directors of both companies and will soon be submitted to stockholders for approval.

New Electrical Power System for Missiles and Aircraft



Sundstrand Controlled-Speed Motor integrated with alternator provides minimum weight and envelope. Leland Electric's alternator is shown here.



Oscillograph trace of power-generating system performance with basic flyball governor. Governor trimming methods provide more precise control.

Operates off general hydraulic system, provides 4 kva rated power, capable of 100% overloads

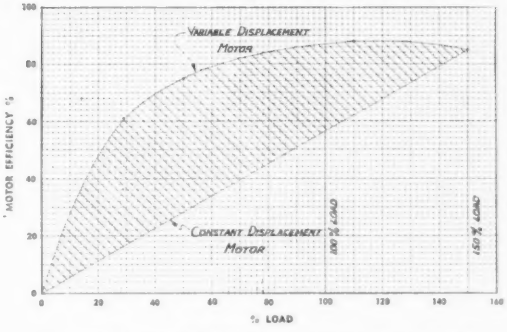
Use of a Sundstrand controlled-speed, variable-displacement hydraulic motor to drive a 400-cycle alternator provides an emergency and isolated electrical power-generation system with many desirable characteristics.

High efficiency throughout the operating range is assured because speed of the motor is controlled by varying the displacement to match the required torque output. The motor takes only that flow of oil from the general hydraulic system required to maintain the driven load. This eliminates the inefficient throttling necessary in a fixed-displacement motor system. There are no discontinuities in speed control from no load to full load.

The system is capable of handling 100% overloads for extended periods.

Integration of the motor in a common housing with the alternator provides minimum weight and envelope . . . maximum resistance to shock and vibration . . . and increased reliability. The integrated package also permits cooling the alternator with oil when air cooling is impractical.

The motor shown has a self-contained flyball governor. Models with external speed controls are available where variable speed is required. The motor itself is particularly suited to driving any load where torque requirements are variable and heating of hydraulic fluid is critical.



Efficiency advantage of variable-displacement motor over fixed displacement motor is shown for loads ranging from 0 to 150% of rating.

- **4 kva with 1.0 power factor**
- **-65° F to +275° F temperature range**
- **Higher temperature models available**
- **Speed control within ±1/10% with trim**
- **±1½% with self-contained governor**
- **One-second transient response**

Mail coupon for complete details.

SUNDSTRAND AVIATION

Division of Sundstrand Machine Tool Company
Rockford, Illinois

Sundstrand-Denver: Denver, Colorado • Western District Office: Hawthorne, Calif.

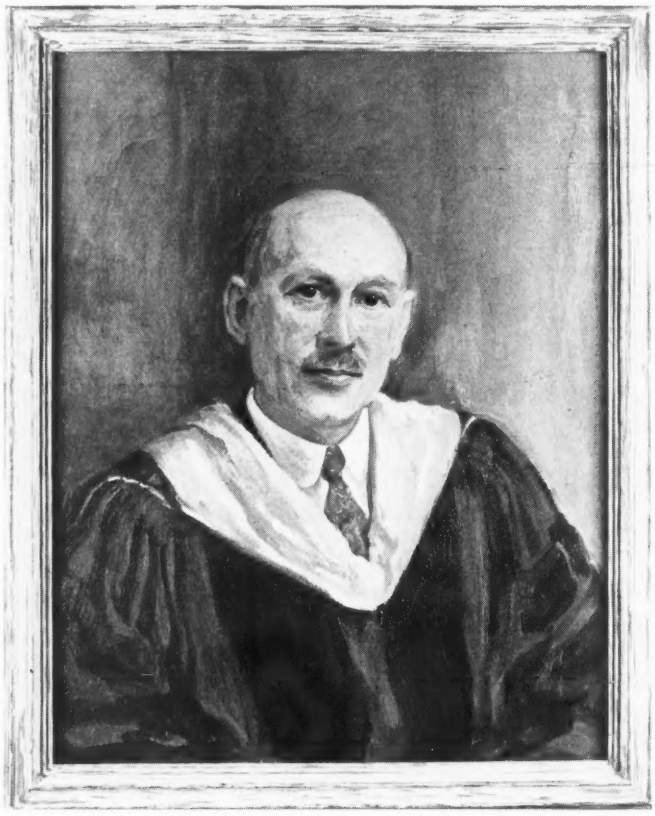
Sundstrand Aviation
2419 Eleventh St., Rockford, Ill.

Send complete data on controlled-speed motor.

Name_____
Title_____
Company_____
Street Address_____
City_____ State_____

☐ Immediate Interest ☐ Reference

New Goddard Portrait for Smithsonian



This new portrait of Robert H. Goddard by Mrs. Emily Burling Waite Manchester of Worcester, Mass., was recently accepted by the Smithsonian Institution for inclusion in the new display of early Goddard rockets now in process of construction at the National Air Museum.

Lessons of Peenemuende

(CONTINUED FROM PAGE 20)

continuity in missile projects. Programs of this type simply cannot be changed overnight to satisfy the whim of a new commander.

Soldiers with technical backgrounds formed the backbone of Peenemuende. Inside the fence, they worked and were treated as civilians, and even received the same salaries as civilians doing comparable jobs. No problems of rank ever arose. It was not at all uncommon to see a major working at the plant under a non-com.

Scientists from universities and research institutes were called in only if there was a scientific problem to solve which we could not solve ourselves. When they were called upon, it was to *solve* a problem, not to discuss it or philosophize about it.

It's a far cry from today, when a simple question asked of a scientist brings a 500-page report on the subject, containing a good deal of highly interesting theory and speculation, and, possibly, the answer, which often is contained in a footnote on page 357. We don't have the time to wade through reports of this kind. What we want are answers—short and to the point.

Incidentally, I'd like to point out parenthetically that space flight is today no longer a scientific problem. It's an engineering problem, and we should get along with the job, rather than theorize about it.

German industry worked on component parts according to specifications set up at Peenemuende. One innovation we introduced was that of the traveling engineer, who went from plant to plant to check on production problems. He was responsible for a particular part of the weapon system and could authorize changes or modifications without prior permission from headquarters. When he returned to Peenemuende, he would inform us of any changes that had been made, and these would be included in the blueprints and specifications.

Today, making even the slightest modification—changing a nut to a bolt, or even changing the size of a bolt—is not up to the company producing the missile, but involves getting official approval from half a dozen different offices.

At Peenemuende, we found that mass production of a big rocket could be accomplished within two years of the first successful firing of a prototype. The Russians announced a successful ICBM firing last March. Need any more be said?

Testing, testing, testing, under simulated flight conditions, was our fundamental approach. Later in development, and again in production, more and more of these tests, at first believed essential, were dropped. Toward the end, we were manufacturing 30 V-2's a day and had hot-run tests of as many as 30 engines on one static test stand within eight hours.

Is there any facility in the U.S. where this could be accomplished today, more than 15 years later?

Firing Problems

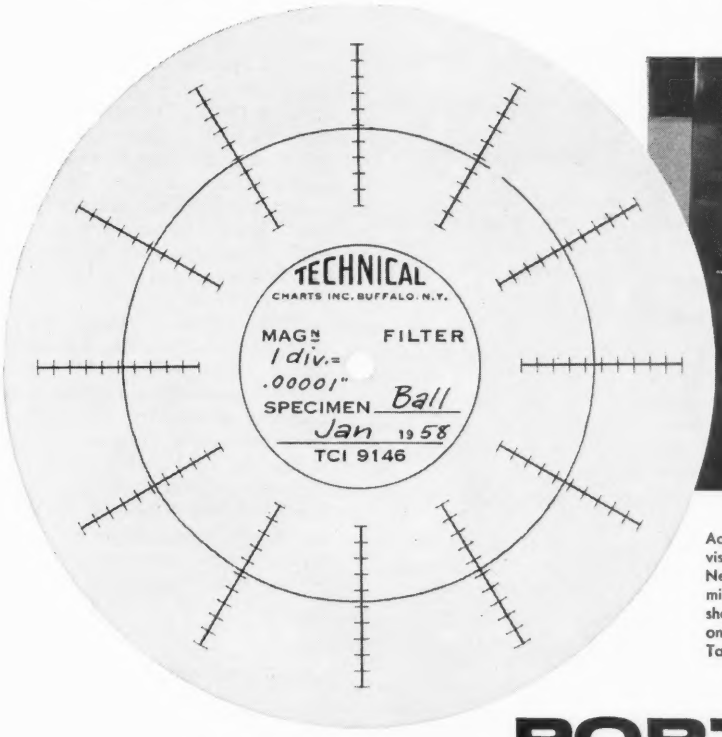
We also learned that a complicated weapon system of this type cannot be fired according to a precise schedule, but only when it is thoroughly tested and ready for launching. I mention this only in view of the fact that so much has already been said about our ability to retaliate against an enemy missile attack by launching our own missiles within five minutes after such an attack.

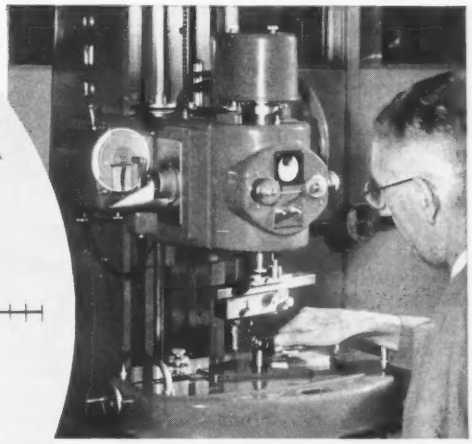
In the development phase at Peenemuende, we were very careful to separate all command activities from launching activities. We learned from experience to leave the launching people alone. As a matter of fact, there wasn't even any telephone communication between the launch area and headquarters at Peenemuende, and, when I wanted to see a launching, I would watch it secretly from the forest nearby, instead of peering over the launching officer's shoulder.

Needless to say, the recent Vanguard TV-3 launching might be held up as a horrible example of the wrong way to go about it.

Another thing we learned was that warhead size and propellant combination must be fixed before you start making calculations for a big rocket. Neither can be changed during development work. If changes are made,

ND FACTS





Accuracy measured in millionths of an inch, made visible to the human eye. Steel balls, the heart of New Departure precision ball bearings, held to 5 millionths of an inch or less in sphericity. Graph at left shows sphericity variation of a ball on the order of one millionth of an inch (.000001") measured by Talyrond Machine. Graph radial divisions are .00001".

PORTRAIT of PRECISION!

The extreme accuracy of New Departure ball bearing component parts is now playing a vital role in successful missiles for the Army, Navy and Air Force. Above —typical bearing parts, less separator —unretouched photograph.

A mechanism is only as accurate and reliable as the bearings supporting its moving parts. For the designer the problem is how to achieve the essential rigidity or *accuracy* of *location*, yet be assured of extreme *freedom* of *rotation*.

A "tip-off" to the solution lies in the chart above—super-precise steel balls, the heart of New Departure precision ball bearings. For, with balls held to 5 millionths of an inch or less out-of-roundness and other bearing parts finished with comparable care, such bearings can be mounted and *preloaded* to provide the hairsplitting exactness of location and *ease of rotation* required of the finest precision instruments.

The AChiever guidance system proved in tests of the Air Force's Thor ballistic missile demands tolerances often measured in millionths of an inch, as is the case with the New Department ball bearings on which the AChiever's precision gyros turn.

1908–1958
GM
FORWARD FROM FIFTY

ND NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

all earlier work becomes a waste of time and money.

We also had to be practical at Peenemuende. We weren't looking for an idea rocket. We just wanted something that worked.

We also learned that it is extremely important to bring production and operations people into the picture at a very early stage. In fact, you can't bring them in too soon. It's not enough to rely on design engineers alone. Production men must be in on the engineering end of the project.

Close cooperation between engineers and production people is imperative. At Peenemuende, we had a regulation which called for all division, section and branch chiefs to spend at least an hour a day at the production plant, talking to people who handled the hardware and learning about their problems.

Teamwork Is Vital

In this country, we have an Iron Curtain that separates the engineers and production people.

Experience and teamwork are vital to a missile development program. Failures should not be blamed on anybody. There's no need for me to dwell here on the many failures we had with the V-2. Why, then, should we become so upset over a Vanguard blowup?

Strong leadership is essential to the success of such a propect. The man who heads up the project must be able to understand the language of the specialists working for him, to evaluate the work that is being done and to set goals even in specific fields.

At Peenemuende, even while working on military weapons, we had a clear concept of what was to come next. In the field of long-range guided missiles and in the coming space age, getting an early start on the next phase saves time, money and energy. We were fully aware of future possibilities. According to our thinking, this was our schedule:

1. Automatic long-range single-stage rockets (A-4 or V-2)
2. Automatic long-range gliders (A-9)
3. Manned long-range gliders (A-9B)
4. Automatic multistage rockets (A-9/10)
5. Manned hypersonic gliders (A-9B/10)
6. Unmanned satellites
7. Manned ferry rockets to satellite orbits
8. Manned satellites
9. Automatic space vehicles
10. Manned space vehicles

This was for us a natural sequence which would materialize when the necessary powerplants for such vehicles were developed. The need for high-energy propellants, nuclear rockets, and ion and photon rockets was recognized very early in the game.

And yet here we are today, still using the same propellant combinations we were using 25 years ago in Germany. We haven't even succeeded in developing chemical propellants which will provide us with 30 to 50 per cent more specific impulse—combinations like fluorine-ammonia, fluorine-hydrazine and liquid hydrogen-oxygen.

When World War II ended, only 180 Peenemuende people came to the U.S. By contrast, more than 4000 were shipped to Russia, along with all the Peenemuende equipment and the production facilities in Nordhausen. There they worked with their new masters in re-establishing the German state of the art as it had existed in 1945.

In 1947–48, the Russians fired literally hundreds of V-2's, and succeeded in increasing their range from 200 to 700 miles. After that, the group was isolated and returned to Germany. The Russians had learned enough to continue by themselves.

Along with the experience they gained in handling long-range rockets, the Russians also got the Peenemuende way of thinking and the schedule for space conquest we had set up as far back as 1942. The satellites are only the first step. Another look at the schedule is all that's necessary to predict what lies ahead.

Let me conclude with a brief excerpt from a speech I made to my staff at Peenemuende on the day of the first successful V-2 launching, in October, 1942:

"The following points may be deemed of decisive significance in the history of technology: We have invaded space with our rocket and for the first time—mark this well—have used space as a bridge between two points on earth. We have proved rocket propulsion practicable for space travel. To land, sea and air may now be added infinite empty space as an area of future intercontinental traffic, thereby acquiring political importance. This is the dawn of a new era in transportation, that of space travel. . .

Space Landings

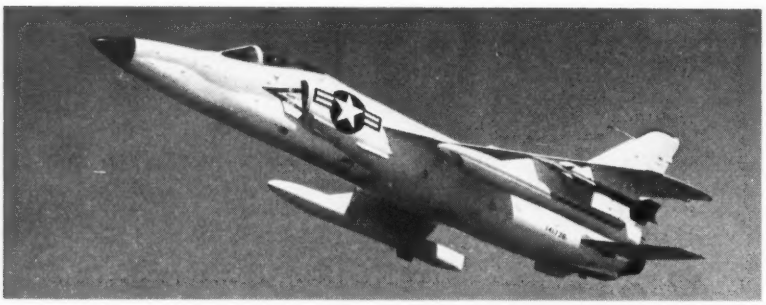
"So long as the war lasts, our most urgent task can only be the rapid perfecting of the rocket as a weapon. The development of possibilities we cannot yet envisage will be a peacetime task. Then the first thing will be to find a safe means of landing after the journey through space. . ."

Here it is 15 years later, and we still haven't solved that problem. Even more important, we are killing the imagination and initiative needed to solve such problems.

In the first summary I wrote after Peenemuende was overrun, in May, 1945, I noted that the first nation with a manned artificial satellite would be a world leader. I still believe this to be true—and, today, perhaps more true than ever.

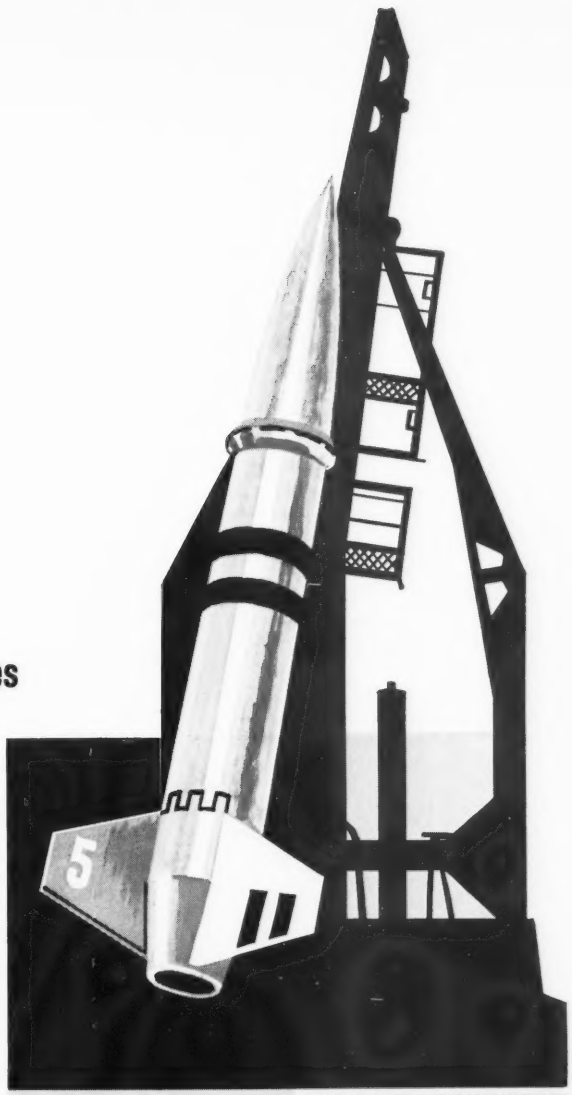
A centralized agency to follow through with the program we envisaged at Peenemuende more than 15 years ago is imperative if we, as a nation, are not only to keep pace with, but surpass, the Russians in the field of space flight.

But the time to start doing something about it is right now. I have no fears about the next five years. It's the five years after that which are dangerous. If we fail to take the necessary steps now, today, we're in trouble.



New Punch for Navy

This F11F-1 Tiger, packing the deadly Sidewinder air-to-air missile, is being built by Grumman for the Navy. The carrier-based fighter, first plane to incorporate "area rule" (pinched waist) concept in its fuselage, recently proved its Sidewinder-launching capabilities in all flight conditions.

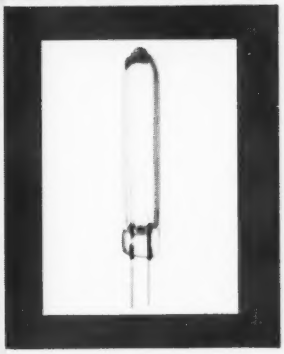


medicine and missiles

Because it represents a totally new idea, Decker's T-42 ionization transducer has evinced interest from men engaged in both the taking of life and the saving of life.

It has brought a hitherto unknown degree of accuracy to the study of the heart, of cancer, and the measurement of blood pressures . . . as well as the measurement of RAM and ambient atmospheric pressure.

But like nuclear energy, the T-42 has no soul. It can deal death or defy it as *you* wish.



THE DECKER CORPORATION

Bala Cynwyd, Pa.

whenever a new development takes place, it is based on ionization and electrical gas discharge

people in the news

APPOINTMENTS

Fred S. Miller, 1955 winner of the AMERICAN ROCKET SOCIETY Hickman Award, has been promoted to manager, solid propellant production, at the Aerojet-General Corp. Sacramento solid rocket plant. Miller originated the use of asphalt as a rocket fuel, which led to large-scale production of the first JATO units.

Ellefson

Richardson

Bennett S. Ellefson and **Howard L. Richardson,** vice-presidents of Sylvania Electric Products, Inc., have been elected senior vice-presidents. Ellefson will be in charge of engineering and research as well as the company's research labs; Richardson, electronic systems and special tubes.

Arthur J. Cussen, former head of Infrared Div., Naval Ordnance Lab., Corona, Calif., has assumed management of the newly formed Infrared Standards Laboratory, Engineering and Production Div. of Infrared Industries, Inc.

C. A. Briggs, former Navy Captain and BuAer representative in Dallas, Tex., has joined Chance Vought Aircraft as chief of research and development.

Maj. Gen. Egbert Frank Bullene, retired Army chief chemical officer, has been elected to the board of directors of the new explosive ordnance group, Holex, Inc.

Bullene

Hall

Lockheed Aircraft Corp. has appointed **D. J. Gribbon,** director, Manufacturing Branch, Missile Systems Div. **Harvey C. Christen,** quality control director, Marietta, Ga., Div., has assumed the equivalent position at Burbank, succeeding George H. Prudden, retired. **O. Ernest Erwin,** chief inspector, Burbank factories A-1 and B-6, has succeeded Christen.

Irwin A. Binder has joined The Ramo-Wooldridge Corp. as vice-president, manufacturing. He formerly was assistant general manager, Tapco Plant, Thompson Products, Inc.

Albert C. Hall, former general manager, Research Laboratories Div., Bendix Aviation Corp., has been named director of research for The Martin Co. He will direct the company's technical activities on the Titan ICBM project. Dr. Hall was founder of the MIT Dynamic Analysis and Control Laboratory.

Bendix Aviation Corp. has appointed **Winston E. Kock,** formerly chief scientist, Systems Div., to replace A. C. Hall as general manager of its Research Laboratories Div., Detroit. **Charles Edwards** and **Gerald A. Rosselot** have been named assistant directors in charge of technical activities and administration, respectively, of the Research Div. **Arthur C. Omberg,** former assistant general manager, has been upped to general manager, Missiles Section, Products Div.

Joseph M. Martin Sr. and **Paul L. Ashway** have joined the Datalab Division of Consolidated Electrodynamics Corp. as managers of the Design Dept. and Fabrication Services, respectively. Martin was formerly chief production engineer, Servomechanisms, Inc.; Ashway, vice-president, assistant secretary and plant manager, William Miller Instruments, Inc.

Myron G. DeFries has been appointed head of the Chemistry Group of Atlantic Research Corp. Before joining AR, DeFries was chief of the test section at the Army Prosthetics Research Laboratory.

Two Navy officers, experts in submarine design, have been added to the Polaris Special Projects Group. **Capt. James M. Farrin,** Commander of the Philadelphia Naval Shipyard, has been appointed special assistant for ship design and production; **Capt. Henry A. Arnold,** repair superintendent at the Pearl Harbor Naval Shipyard, has been designated assistant for ship production. Both will concentrate on design problems involved in the construction of nuclear-powered submarines capable of launching Polaris.

Lieut. Gen. Arthur G. Trudeau has succeeded Lieut. Gen. James M. Gavin as the Army's Chief of Research and Development. Gen. Trudeau has been serving as Army assistant chief of staff for intelligence.

Robert R. Johnson, chief engineer, Minnesota Rubber Co., has been promoted to vice-president, engineering.

National Academy of Sciences-National Research Council has appointed **Ernest W. Volwiler,** president and general manager, Abbott Laboratories, as chairman designate of the Academy-Research Council's Div. of Chemistry and Chemical Technology. Dr. Volwiler will assume the chairmanship on July 1, succeeding Frederick D. Rossini.

Edward R. Neumann has been named manager of the Missile Products Div., Fruehauf Trailer Co.

Col. Frank J. Shannon (USAF-Ret.) has been appointed manager, technical field service, Packard-Bell Electronics Corp.

DeFries

Shannon

Willam C. McDonald, former works manager, Non-Linear Systems, has been made vice-president in charge of engineering and manufacturing.

Dean A. Watkins, professor of electrical engineering and director, Electron Tube Lab., Stanford University, has been appointed president of the newly formed Watkins-Johnson Co., which will deal in research, development and manufacture of electron devices. **H. Richard Johnson,** former head of Microwave Tube Dept., Hughes Research Labs., has been named vice-president.

NACA has reappointed three Cal Tech professors to committee posts. **Lester Lees,** professor of aeronautics, will again serve on the Subcommittee on Fluid Mechanics in 1958; **Stanford S. Penner,** a professor of jet propulsion, on the Combustion and Propulsion Panel, NATO Advisory Group on Aeronautical Research and Development; and **Frank E. Marble,** professor of jet propulsion and mechanical engineering, as alternate member repre-

senting the U.S. on the panel.

Andrew A. Mueller has been named to the new position of Chief of Engineering Laboratories, Chicago Aerial Industries.

Alan R. Gruber has been appointed assistant chief research engineer to head nuclear systems research in the Astro Div. of Marquardt Aircraft Co. Astro is the new designation for Marquardt's Long-Range Planning and Research Div.

Neil T. Fitzmorris has joined Redel, Inc., as a chemical engineer in the Research & Development Div. to specialize in rocket propellant ignition and combustion studies.

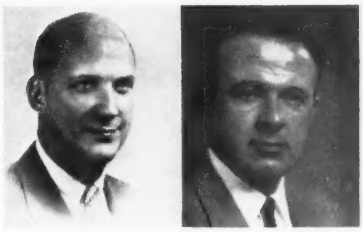
T. D. Smith has been named assistant missiles design engineer (mechanical), Santa Monica Div., Douglas Aircraft Co.

Cornell Aeronautical Laboratory has named **Herbert Nye,** assistant head, Laboratory's Systems Requirements, director of the new Laboratory office in the Washington, D.C., area, formed recently under a $1.5 million Army contract for development of an improved combat surveillance system. **Walter Brewer,** assistant head, Weapon Systems Design Dept., will serve as acting deputy director and head of the Systems Synthesis and Evaluation Group. Other group heads are **Mark Foster,** Technical Characteristics, and **Arthur Whiting,** Systems Requirements. **John Egly,** administrative engineer, Safety Design Research Dept., becomes administrative assistant.

NSF has approved the appointment of **Aden B. Meinel** as the first director of the new National Astronomical Observatory at a site to be selected in Arizona. Dr. Meinel is on leave from the Yerkes and McDonald Observatories, where he is associate director.

J. L. Atwood, president of North American Aviation, has been named president of Astrodyne, Inc., and **R. W. Thomas,** vice-president for research and development of Phillips Petroleum Co., has been named vice-president of the newly formed joint NAA-Phillips solid rocket company. Top operating officials of the new company are **J. A. Reid,** formerly director of research for Phillips, named vice-president and general manager, and **T. E. Myers,** previously manager of plant engineering at NAA's Rocketdyne Div., appointed vice-president and assistant general manager.

Robert A. Lehman has been appointed executive vice-president, general manager and a member of the board of American Electronics, Inc. He was formerly president and board chairman of Cal-Air Engineering, Inc.



Lehman Degen

Joseph F. Degen has been made vice-president in charge of manufacturing for Weston Electrical Instrument Corp.

Townsend Co. has announced the formation of a new subsidiary, Townsend Engineered Products, Inc.

Wladimir A. Reichel has been appointed senior vice-president of Norden-Ketay Corp. He was formerly senior vice-president for engineering of General Precision Equipment Corp.

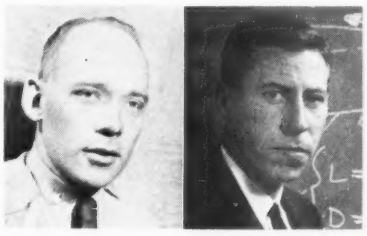
Reichel Guterman

Frederick H. Guterman has been elected a vice-president of Allen B. DuMont Laboratories. Formerly assistant vice-president, sales and planning, at American Bosch Arma Corp., he will be vice-president and general manager of DuMont's Industrial and Military Equipment Div.

J. R. Madigan has been promoted to chief engineer and **Margaret C. Arst** has joined the R&D staff of Hoffman Semiconductor Div. of Hoffman Electronics Corp. In addition, a new Application Engineering Dept. has been formed by the division, with **Perry L. Toback** as its head.

HONORS

Maj. David G. Simons, chief, Space Biology Branch, Aero Medical Field Laboratory, Holloman AFB, N. M.,



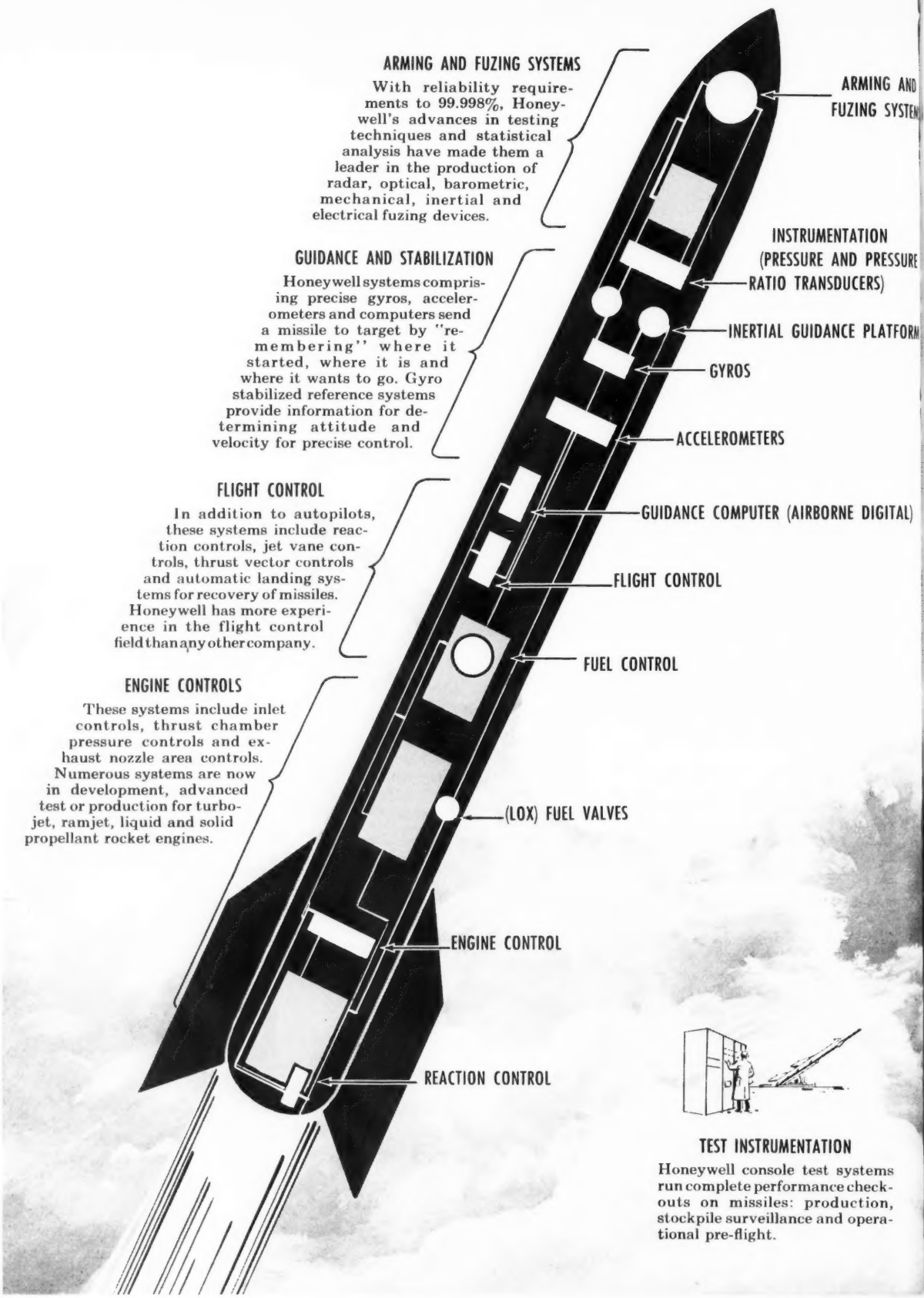
Simons Eggers

and **Alfred J. Eggers Jr.,** chief, Supersonic Wind Tunnel Branch, Ames Aeronautical Laboratory, have been named Outstanding Young Men of America for 1957 by the U.S. Junior Chamber of Commerce. They were among 10 men chosen for the honor.

The Navy has presented its highest public service award and citations to the director of the Applied Physics Laboratory, The Johns Hopkins University, and four members of his staff in recognition of their contributions to the development of the Terrier guided missile. Distinguished Public Service Awards were presented to **Ralph E. Gibson,** director, **Richard B. Kershner, Alexander Kossiakoff, Robert C. Morton** and **Henry H. Porter.** Meritorious Public Service Citations, the Navy's second highest award, went to **Alvin R. Eaton Jr., Thomas W. Sheppard, Roland W. Larson** and **Richard T. Ellis.**

Maj. David G. Simons has received the John J. Jeffries Award of the Institute of the Aeronautical Sciences for his balloon research flight to 102,000 ft. **Raymond L. Bisplinghoff,** professor of aeronautical engineering at MIT, received the Institute's Sylvanus A. Reed Award for developing ways to calculate aircraft loads and stresses, while **Clarence A. Syvertson,** Stanford University, won the Lawrence Sperry Award for solving problems of flight at speeds 30 times that of sound, and **Arthur E. Raymond,** vice-president—engineering, Douglas Aircraft Co., won the 1957 Guggenheim Medal "for notable achievements in the advancement of aeronautics."

Col. John P. Stapp, head of the Air Force "Man in Space" Committee and Vice-President of the AMERICAN ROCKET SOCIETY, received the first Girard Perregaux Geophysical Award recently for his supervision of and personal participation in vital research in human factors in rocket flight. Accompanying the award was a specially designed gold Gyromatic 39 wristwatch made by the company, the first such watch in this country.


ARMING AND FUZING SYSTEMS
With reliability requirements to 99.998%, Honeywell's advances in testing techniques and statistical analysis have made them a leader in the production of radar, optical, barometric, mechanical, inertial and electrical fuzing devices.
GUIDANCE AND STABILIZATION
Honeywell systems comprising precise gyros, accelerometers and computers send a missile to target by "remembering" where it started, where it is and where it wants to go. Gyro stabilized reference systems provide information for determining attitude and velocity for precise control.
FLIGHT CONTROL
In addition to autopilots, these systems include reaction controls, jet vane controls, thrust vector controls and automatic landing systems for recovery of missiles. Honeywell has more experience in the flight control field than any other company.
ENGINE CONTROLS
These systems include inlet controls, thrust chamber pressure controls and exhaust nozzle area controls. Numerous systems are now in development, advanced test or production for turbojet, ramjet, liquid and solid propellant rocket engines.
ARMING AND FUZING SYSTEM
INSTRUMENTATION (PRESSURE AND PRESSURE RATIO TRANSDUCERS)
INERTIAL GUIDANCE PLATFORM
GYROS
ACCELEROMETERS
GUIDANCE COMPUTER (AIRBORNE DIGITAL)
FLIGHT CONTROL
FUEL CONTROL
(LOX) FUEL VALVES
ENGINE CONTROL
REACTION CONTROL
TEST INSTRUMENTATION
Honeywell console test systems run complete performance checkouts on missiles: production, stockpile surveillance and operational pre-flight.

How many brains make a missile?

Control systems are the brains that guide, control and explode missiles. Honeywell can build any of these integrated control systems or sub-systems.

Honeywell is now developing and producing systems, sub-systems and components for the following missiles: Sidewinder, Honest John, Asroc, Corporal, Thor, Redstone, Wagtail, LaCrosse, Sergeant, Little John, Titan, Falcon, Vanguard and many *classified* applications. This broad experience in missiles, as well as a solid background in rockets and aircraft systems, makes Honeywell the logical company to aid you in your airborne control problems. Contact Minneapolis-Honeywell, Military Products Group, 2600 Ridgway Road, Minneapolis 13, Minnesota.

Honeywell

H Military Products Group

from the patent office

BY GEORGE F. McLAUGHLIN

Missile Tracking System

It has been the custom to determine the velocity and flight path of rockets and guided missiles by tracking them with pulse radars such as the SCR-584. However, a radar receiver remains inoperative until after termination of the transmitted pulse, and tracking information cannot be obtained while the object is at close range. Another disadvantage is the radar's inability to distinguish a rocket or missile proper from such temporary structure as a carriage or booster.

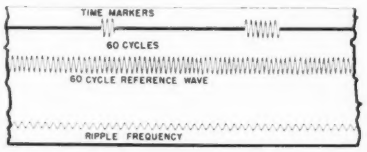
A new invention provides a missile tracking system overcoming the above disadvantages.

Precise speed and trajectory measurements of rockets are obtained by a continuous wave transmitter and spatially dispersed receivers remotely located with respect to the launcher. The respective antennas of the transmitter and each receiver are disposed to permit the transmitter to illuminate the rocket with most of its energy, but permit a small amount of the energy to reach each receiver directly from the transmitter. In addition, each antenna receives energy reflected from the rocket. The ripple frequency in each receiver depends upon the rocket speed and its relative bearing with respect to the transmitter and receiver. A comparison of the ripple frequencies appearing simultaneously at each of the receivers provides data for computing the speed and course of the rocket at any instant.

Centrally disposed with respect to the receivers is a transmitter connected to an antenna having no directional characteristics with respect to the rocket trajectory. The antenna consists of a horizontally polarized half wave dipole with a director vertically stacked one-tenth of a wave length above it to provide a greater upward concentration of energy. The antenna is oriented so that its elements lie in the same plane as the rocket trajectory.

A separate receiving antenna is provided for each receiver. The receiving antennas must also be horizontally polarized and have good vertical sensitivity and minimum horizontal sensitivity in the direction of the transmitter. Likewise, they must be oriented so that the rocket trajectory lies in their plane of polarization.

Tracking system showing launcher, transmitter, receivers and recorders.



Portion of three-pen recorder chart.

Receivers are each connected to one of a group of recorders. The firing switch at the launcher has a line to each recorder so that they may be simultaneously put in operation in synchronism with the firing of the rocket.

Each recorder is a three-pen unit for making a chart. One pen records time markers recorded at half-second intervals, every fifth second being denoted by a longer time marker. The central trace is a steady continuous 60-cycle reference wave. The bottom trace is the ripple frequency taken from the recorder's respective receiver output.

The receiver is a Hallicrafter S-27 and the transmitter is operated at 75.4 megacycles at about 50 watts, using a horizontally polarized dipole with one director. A well-filtered power supply must be used to avoid any 120-cycle waves which might be confused with receiver ripple. A crystal-controlled transmitter avoids spurious ripple from transmitter frequency variation.

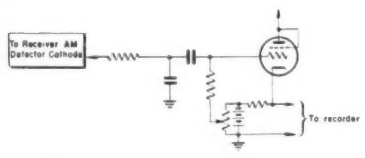
A Doppler effect is observed in each receiver, which is tuned to the transmitter frequency, since each receiver is simultaneously detecting a signal traveling horizontally from the transmitter to the receiver and a component of this signal reflected from the rocket. As the rocket is moving, reflected energy will be above or below the transmitter frequency, depending on whether the rocket is moving toward or away from the receiver and transmitter involved.

Frequency shift in the reflected energy combined with the 75.4 megacycles from the transmitter produces a difference frequency, which may vary between zero and a few hundred cycles; this difference is the recorded ripple frequency.

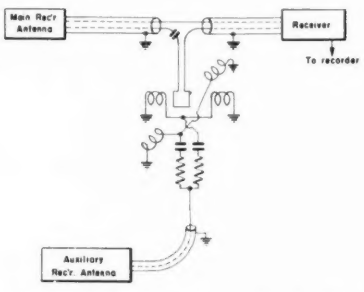
In addition to the method of selecting receiving antennas which are insensitive horizontally as a means of minimizing the direct received energy, the same effect can be obtained by adding a second antenna to each receiver which is oriented to receive no reflected energy, but only direct energy from the transmitter. The signal from this antenna is fed to its receiver through a coupling device including a pickup coil arranged for rotation and also withdrawal with respect to the field coil so that voltage of any phase and amplitude (up to a certain maximum) can be impressed on the receiver in series with the voltage from the main receiving antenna via the pickup loop.

This signal is adjusted in phase and amplitude by manipulation of a coil so that it will buck out all but the desired amplitude of direct pickup from the transmitter. The signal from the antenna is coupled to coils through RC phase shifting circuits. The condensers give 45 deg lead in one pair of coils, and 45 deg lag in the other. Resistors are of the non-inductive type, and high enough to make the circuits broadly resonant.

Tracking System (2,817,081). Walter Van B. Roberts, Princeton, N. J., assignor to the U. S. A.



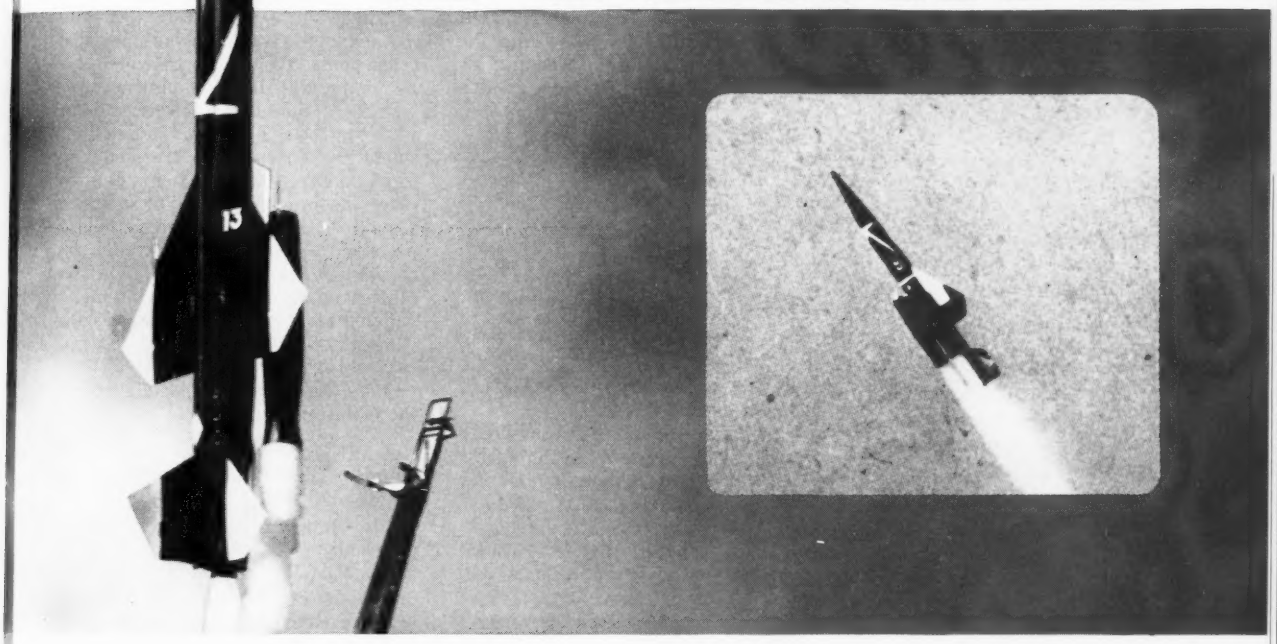
Circuit of connections between each receiver and its associated recorder.



Circuit of coupling device for feeding signals from an auxiliary antenna.

Preserver of Peace...

BOMARC



Official U.S. Air Force Photo

It tracks down an enemy at 300 miles

Described as the most potent of all ground-to-air defense missiles, the Bomarc pilotless interceptor, designed by Boeing, stands poised for the destruction of any "enemy" bomber within a 200-300 mile range. Its booster rocket has the power to hurl it more than 60,000 feet straight up; then, powered by two ramjet engines, it hurtles by electronic instinct to its target at up to 3 times the speed of sound. For this guardian of our homes and way of life, RCA has been privileged to supply important advance components of the guidance system.

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Through All Kinds of Weather, the Fuel Train . . . . .

This new fuel train, which can transport 5000 gal of fuel or other liquids over rugged terrain, sand, mud, swampland, ice and snow, was developed for the Army's Transportation Research and Engineering Command by the Four Wheel Drive Auto Co., Clintonville, Wis. Towing the train is a "pillow-tire" FWD Teracruzer of the type used by the Air Force for ground support of the Matador guided missile.

Flight Space and the Satellites

(CONTINUED FROM PAGE 33)

I am convinced that the term "air space," as used in the Paris Convention in 1919, was there meant to include only those parts of the atmosphere above the surface of the earth where gaseous air is sufficiently dense to support balloons and airplanes, the only type of aircraft then in existence. The annexes to the Paris Convention describe an aircraft as "any machine that can derive support in the atmosphere from the reactions of the air." These annexes were part of the Paris Convention. The annexes to the Chicago Convention of 1944 now in force, although legally not part of the Convention, have been accepted by member states, which include practically all of the great flying nations with the exception of the U.S.S.R. The definition of "aircraft" in the annexes to the Chicago Convention is the same as that in the annexes to the Paris Convention.

Definition Needed

My views today are just as they were in 1956, when these matters were discussed at some length at the annual meeting of the American Society of International Law. I then said what I now wish to repeat, namely:

"The Chicago Convention contains no definition of air space, but it may well be argued that, as it was adapted from the Paris Convention, it deals with no areas of space other than those parts of the atmosphere where the gaseous air is sufficiently dense to support balloons and airplanes. . . .

"Nothing in the Chicago Convention precludes the possibility of state sovereignty being extended by international agreement, or by unilateral force, above the areas in which the airplane and balloon can be used, but there is certainly no basis on which any customary international law can as yet be considered applicable to such higher areas."

Any careful reading of what I said then and have since said as to possible further upward extension of air sovereignty will disclose that I have always insisted that an agreement would be needed before national sovereignty of any state could be recognized in areas above those where sufficiently dense gaseous atmosphere will exist to provide aeronautical lift for airplanes and balloons.

It may be useful to examine the present status of the practical use now being made of this atmospheric space. Maj. David G. Simons has ascended in a specially constructed balloon to a distance of approximately 100,000 ft, or somewhat over 19 miles. A Canberra B-2 aircraft has been credited with an official altitude height of approximately 70,100 ft, or about 13 miles, which I believe is the highest official record to date. An experimental rocket-powered X-2 reportedly reached speeds of a least 1900 mph and attained a height of approximately 24 miles.

Although rocket power has made it possible for aircraft requiring atmospheric support to ascend far above the areas where they might be driven by older powerplants, I do not feel the legal position has been altered, since they are still operating within the "air space" which is part of the territory of the state below. However, a new and completely different problem will arise if future types of aircraft driven by rocket power ascend through the atmosphere in normal flight, and then continue beyond as rocket-powered space craft.

Returning, then, to the major problem as to where territorial "air space" ends and "outer space" begins, let us turn our attention to a series of international events which appear to indicate the beginning of a new rule of customary international law, holding that "outer space" is not part of the territory of the state below.

In 1955, the U.S. announced a program of planned satellite flights in aid of the International Geophysical Year. The proposed satellites were to contain instruments to study various physical phenomena, the details of which are not important here. Shortly afterwards, the U.S.S.R. indicated a similar plan. So far as I can ascertain, neither the U.S. nor the U.S.S.R. asked any formal permission of other states to place the proposed satellites in space several hundred miles above those parts of the earth which would be covered by the flight orbits. On the other hand, as is well known, no international flight by aircraft of any state through the atmospheric territorial space of another state is permissible without the general or specific authority of the state affected.

Satellite Flights Unprotested

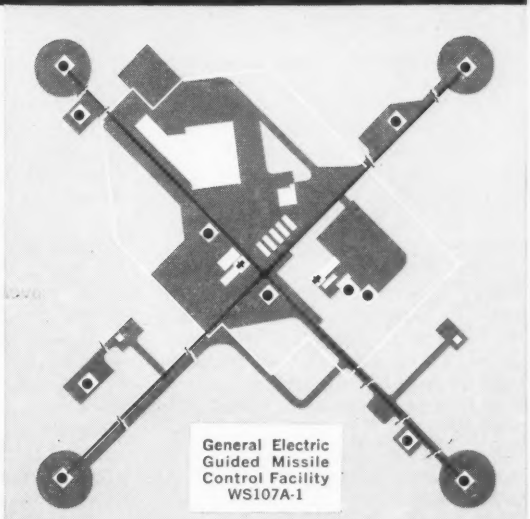
Also, no record exists that any state protested against the proposed international satellite flights. While it has been suggested that the various agreements between the scientific committees promoting IGY may have been supported sufficiently by the several governments concerned so as to be considered legally equivalent to international agreements permitting such satellite flights, this argument would fail in so far as those states are concerned which are not part of the IGY program and over whose territories the satellites would proceed.

Next, in order of time, was the statement in President Eisenhower's January, 1957, "State of the Union" message to the effect that the U.S. was willing to enter any reliable agreements which would mutually control outer space missile and satellite development. A few days later, the U.S. representative addressing a committee of the United Nations General Assembly is reported in the press to have said that the "first step toward the objective of assuring that developments in outer space would be devoted exclusively to peaceful and scientific purposes would be to bring the testing of such objects under interna-

GRADUATE EE'S: GENERAL ELECTRIC DISCLOSES HIGH PRIORITY PROGRAM FOR ATLAS GUIDANCE SYSTEM. MANY POSITIONS OPEN IN ELECTRONIC MISSILE TECHNIQUES=

ACCURACIES ON ORDER OF 1 PART IN 10 MILLION

required for portions of G.E.'s ICBM ATLAS Guidance System



Delivering an ICBM over a > 5000 mile trajectory into the target area demands a guidance system of unprecedented accuracy—and this is the calibre of the electronic system General Electric engineers are creating for ATLAS.

But achieving designated accuracies and reliabilities in the laboratory is not enough. *These high standards must be maintained in actual operational environments, with virtually no interruption or degradation.*

CAREERS IN STEP WITH THE FUTURE

Engineers who join the Missile Guidance Product Section of G.E. are doing more than hastening development of one of the nation's most urgent programs — guidance for ATLAS. As Manager of the Section Richard L. Shetler states: *"With this job behind us, there will remain no significant obstacle to the practical guidance and navigation of other space vehicles."*

PROGRAM ACCELERATION OPENS UP WIDE RANGE OF POSITIONS IN:

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tional inspection and participation."

Later, in July, a proposal was put before the Subcommittee of the Disarmament Commission meeting in London, which suggested the inclusion in a possible Disarmament Convention of the "control of objects entering outer space." This was supported by Canada, France, the United Kingdom and the U.S.

The courses of the orbits of the Soviet satellites are such that they have probably passed over the surface territory of every member of the United Nations, and many other states as well. I have not been able to find any record that states have protested against such flights as violating their territorial rights.

While these flights were continuing, disarmament proposals were adopted by the Political Committee of the United Nations. A resolution sponsored by Canada, France, the U.K., the U.S. and a number of other nations stated that the Disarmament Subcommittee should give priority to reaching a disarmament agreement, which, on entering into force, would provide for various things, including the "joint study of an inspection system designed to ensure that the sending of objects through outer space will be exclusively for peaceful and scientific purposes." This is practically the same proposal suggested earlier in the Disarmament Subcommittee.

UN Resolution

According to press reports, the Political Committee proposal has been approved by the U.N. Assembly.

Taking all these official and semi-official acts together, I feel as a lawyer that the course of international conduct since the satellite flights were first announced is consistent with no theory other than the acceptance of the principle that "outer space" is not part of the territory of any state and may be used by all states as freely as the high seas are now used for surface shipping.

This emphasizes, however, the present major difficulty—what is meant by "outer space." I submit that, immediately above the area of admitted national sovereignty, namely where sufficient gaseous atmosphere exists to support aircraft or balloon flight, is an area in which there appears to be sufficient gaseous atmosphere to *affect* flight.

Observations of the two Soviet satellites indicate that the lower portion of the orbits of both Sputnik I and II are closer to the earth than some earlier scientific analyses had deemed practical for effective satellite flight. At the same time, the figures show that these lower parts of the orbit must be within an area in which there is sufficient gaseous atmosphere to create some "drag," affecting the period of time during which the satellites may continue on their courses. The same lower parts of the orbits are, however, above those atmospheric areas which would cause sufficient heating to destroy the satellites.

To sum up my views: I believe we are entering a period where international conduct as well as legal doctrine will demonstrate:

1. That the present territory of every State extends upwards only to a point where gaseous air becomes so thin as to provide no aeronautical lift supporting flights of aircraft or balloons.

2. That "outer space," where there is no atmosphere of sufficient density to create "drag" or otherwise affect flight, is now beyond the sovereignty of any state.

3. That an international decision must be made, by treaty or otherwise, to determine the exact future status of those areas of atmopheric space which lie between the areas of practical aeronautical lift and the areas referred to above as "outer space."

The remaining two problems may be dealt with briefly. It is obvious that a satellite is not an aircraft subject to the present existing international regulations. However, I submit that it is quite necessary that future formal international agreements should provide means for such regulation. Such an agreement will certainly require that the state responsible for the launching of the satellite will also be subsequently responsible for its international good conduct.

So far as future regulation of areas of "outer space" which are not part of the sovereignty of any state are concerned, the recommendations recently made by the Commission to Study the Organization of Peace, the research affiliate of the American Assn. for the United Nations, may be of interest. The Commission has recommended that the U.N. should undertake the responsibility of administering certain areas "which are outside the jurisdiction of any State," including "outer space," and that the General Assembly should declare the title of the international community and establish the appropriate administrative arrangements.

In the detailed statement by a study group of the Commission on which these recommendations are based, it was urged that the principle should be accepted that outer space is not subject to ownership or control by individual States but only by the international community, represented by the U.N. In the alternative, it was suggested that international ownership and operation of all or certain types of space craft and verification of flights be adopted as a short-term policy regarding earth satellites, but only after more than one nation had launched such a satellite. These recommendations were drafted before Sputnik I was launched.

International Lawyer's Role

Such proposals pose questions of future international policy. It is the primary province of the international lawyer to determine the present status of the law. At the Washington meeting of the Society of International Law, I went further and suggested for future consideration possible extension of sovereignty by agreement up to 300 miles above the surface of the earth, so as to include areas of "drag." Such a suggestion was entirely tentative, as I said, depending on what was found in IGY research as to actual conditions in upper atmospheric space. Recently, I suggested that it might be advisable to extend such sovereignty by agreement up to 600 miles as part of any disarmament agreement, so as to protect neutral states from the uncontrollable flight of guided missiles on high trajectories.

These are nothing more than statements of my personal views as to possible international policy. They do not in any wise change the carefully considered views which I have expressed earlier with reference to the present status of the law, nor do they reflect the views of any organization with which I am associated or any committees of which I am a member.

However, even this brief review is sufficient to indicate the immediate need for an international effort to work out the legality of present and future space flight projects, of which man-made satellites represent only the first halting steps.

Giant Radio Telescope To Use Maser Amplifier

A 100-ft radio telescope to be built at the University of Michigan will use a maser-type amplifier and have a range of 100 m to a low of 2 cm, and possibly "close to 1 cm." According to Fred T. Haddock, associate professor of astronomy and electrical engineering, this telescope compares favorably with the new Russian telescope, said to receive 2 cm waves. Main advantage of the telescope is that it is a steerable, solid paraboloid of 18 per cent great area, employing a circular rather than a fan beam, and is capable of following any object for 12 hours, compared to less than an hour for the Russian device.

Genie for NORAD

Military officials eye the Douglas MB-1 Genie atomic rocket, to be used by the North American Air Defense Command. Left to right, Group Capt. W. C. McNeill, RCAF; Rear Adm. Walter F. Rodee, Commander, NORAD naval forces; Robert C. Little, chief test pilot of McDonnell F101B Voodoo, which will carry the Genie; and Maj. Gen. Harvey T. Alness, director of operations for NORAD.

Science Moves Ahead: Plugging the Holes

H. M. Davis, Flight Control Laboratory, Wright ADC, Dayton, Ohio, calls our attention to the following exchange of letters which recently ran in a Dayton newspaper:

To the Editor:

"Why does it get dark so early? And what about the record low temperature?

"I sincerely believe the flights to outer space have left holes in our atmosphere. The light which lingered after sundown and the heat which makes life possible are seeping out those holes.

"We had better find ways to plug the holes we have already made or prepare to withstand the conditions of space right here on earth, once our atmosphere has all leaked out."

(Signed) _____

This letter brought the following reply:

To the Editor:

"Mr. —— has raised a serious question about plugging sky holes. My company has been one of several engaged in developing sky plugs that will prevent light and heat from draining out of the atmosphere. Complete success has not been attained but we are confident that within the next year we will have the solution. Meanwhile, the Russians are working on the problem and hope to gain the propaganda advantage of being first to solve it.

"There are two approaches to the solution: First, to plug the holes and, second, to put the entire earth inside a giant self-sealing bag which would act somewhat like a tubeless tire. Such a bag would either be blown up around the earth using a few atomic bombs to create the pressure necessary to inflate it, or it would be suspended beneath a few satellites made for the purpose.

"Of course we are trying the suggested approach—making a sky plug to cover the holes torn in the top of the atmosphere by missiles. These plugs must be airtight and should be transparent. A lightweight material is preferable because sky plugs are lifted to a great altitude before being put into place. Glass is too heavy for this purpose, but plastics apparently will work.

"One of the factors making the job too difficult is that missiles and satellites usually leave jagged holes, and to provide an airtight seal, the holes must first be filled, a gasket made and a special plug designed to fit that particular hole.

"It would help if we had standard size missiles so that a single plug would do.

"Small missiles and off-course missiles sometimes leave holes that are difficult to find. These holes create a slow leak which we hope to correct once the new rocket-powered hole-seeker is perfected."

(Signed) _____

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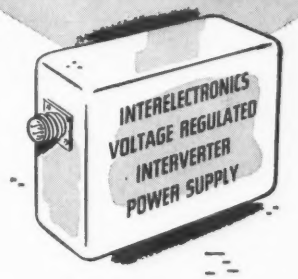
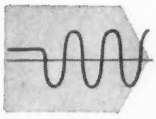
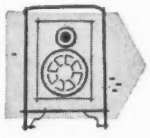
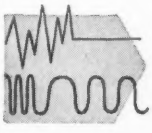
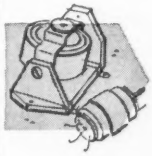
DC to DC and DC to AC solid-state power converters voltage regulated, frequency controlled, for missiles, telemetering, gyros, servos











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government contract awards

Regulus and Lacrosse Equipment

Two contracts for support equipment for Regulus II and Lacrosse missiles have been received by Consolidated Diesel Electric Corp. Three portable test rigs for the Regulus will be supplied to Chance-Vought Aircraft, Inc., and six prototype hydraulic service consoles for use with the launching equipment of the Lacrosse will be built for The Martin Co.

Grumman Is Winner

Winning design for the Navy's recent attack aircraft competition was submitted by Grumman Aircraft Engineering Corp., and is a carrier-based aircraft which will be turbojet-powered, manned by crew of two, for operation at both high and low altitudes.

Convair to Study New Metals

Convair has been awarded a $1,388,044 AF contract to investigate the use of the newer titanium alloys in future supersonic aircraft and missiles. The 18-month study will center on development of manufacturing methods and processes, fabricating techniques and tooling by which components can be produced in production quantities from titanium alloys.

Chrysler Gets $52 Million Jupiter, Redstone Contracts

The Army has awarded Chrysler Corp. $52 million in contracts for missiles. The contracts include $30 million for "partial 1958 purchases" of the Jupiter IRBM and ground equipment. About $21.8 million covers continuing purchases of the Redstone. Both missiles will be built in the government-owned plant at Warren, Mich. Heretofore, Jupiter was produced for developmental testing at ABMA, Huntsville, Ala.

Navy Renews Firebee Contract

A new $6,250,000 contract for advanced model KDA-4 Firebee jet drone missiles has been awarded by the Navy to Ryan Aeronautical Co., extending Firebee production into the latter part of 1959.

$70 Million Snark Pact Pends

Northrop Aircraft has received an AF letter of intent indicating production of more than $70 million worth of additional Snark SM-62 ICBM's and related equipment.

AF Orders 100 Bomarc Missiles, Sets Up Four Tactical Bases

Boeing Airplane Co. will build 100 long-range, supersonic Bomarc missiles for the Air Force. This order comes on the heels of an AF announcement that the first four tactical Bomarc bases will be located at Dow AFB, Maine; McGuire AFB, N. J.; Otis AFB, Mass.; and Suffolk County AFB, N. Y. Bomarc is the spearhead of an entire weapon system developed by Boeing for the AF, and is considered this nation's principal area defense weapon.

AF Orders More Falcons

Hughes Aircraft Co. has received a $19,278,275 contract from the Air Force for advanced versions of the Falcon air-to-air guided missile, designated GAR-1 and GAR-2, guided respectively by radar and infrared radiation.

$100 Million Contract Awarded

The Navy has awarded a $100 million contract to Chance Vought for production of the F8U-3, an advanced, all-weather, Mach 2 jet fighter which CV has been developing under an earlier contract.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

Commander, Hq. AMC, Wright-Patterson AFB, Ohio.

Fuze PDSD, FMU-3/B for rocket aircraft, $76,380, **The Magnavox Co.**, Fort Wayne, Ind.

Engineering services necessary to integrate various aircraft and weapons control systems with the SAGE environment, $509,825, **Hughes Aircraft Co.**, Florence Ave. and Teale St., Culver City, Calif.

Hq., AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Increase in funds, $230,000, **Radiation, Inc.**, P.O. Drawer 37, Melbourne, Fla.

Increase in funds, $50,000, **Potter Instrument Co. Inc.**, Sunnyside Blvd., Plainview, N. Y.

Rocket propellant $38,157, **Westvaco Chlor-Alkali Division** of Ford Machinery and Chemical Corp., 161 E. 42 St., New York, N. Y.

Increase in funds, $85,877, **Cubic Corp.**, 5575 Kearny Villa Rd., San Diego, Calif.

Airframe development program of T-38 jet trainer, $3,150,000, **Northrop Aircraft Inc.**, Hawthorne, Calif.

Increase in funds, $30,950, **Sterling Precision Corp.**, Instrument Div., 34-17 Lawrence St., Flushing, N. Y.

Hq., AF Office of Scientific Research, ARDC, Washington 25, D. C.

Continuation of research on combustion processes in liquid propellant rocket motors, $70,000, **Princeton Univ.**, Princeton, N. J.

Research on study of hypersonic viscous flow phenomena, $35,000, **Rensselaer Polytechnic Institute**, Troy, N. Y.

Continuation of research for properties of air and propellant reactions at high temperatures and pressures, $36,590, **Cal Tech**, Pasadena, Calif.

Research on viscous effects in supersonic flows, $86,725, **Princeton Univ.**, Princeton, N. J.

Hq., Middletown Air Materiel Area, USAF, Olmsted AFB, Pa.

Liquid oxygen, $51,525, **Pacific Oxygen Co.**, 2205 Magnolia St., Oakland 7, Calif.; $73,079, **Air Reduction Co., Inc.**, 150 E. 42 St., New York, N. Y.; $38,600, **California Oxygen Co.**, 511 S. Fullerton Rd., LaHabra, Calif.; $36,208, **Southern Oxygen Co.**, P.O. Box 5087, Washington 19, D.C.; $217,593, **Big Three Welding Equipment Co.**, P.O. Box 3047, Houston 1, Tex.; $46,951, **The Burdett Oxygen Co. of Cleveland, Inc.**, 3300 Lakeside Ave., Cleveland 14, Ohio; $60,651, **Dye Oxygen Co., Inc.**, 3332 W. McDowell Road, P.O. Box 6276, Phoenix, Ariz.; $126,835, **Marks Oxygen Co., Inc.**, 762 Stewart Ave., S. W., Atlanta 10, Ga.

Hq., Oklahoma City Air Materiel Area, Tinker AFB, Okla.

Overhaul and repair of J-35 jet engine components, $106,892, **General Motors Corp., Allison Div.**, Indianapolis, Ind.

Hq., Topeka AF Depot, USAF, Topeka AF Station, Topeka, Kans.

Test stand, $369,800, **Sun Electric Corp.**, Harlem and Avondale Ave., Chicago 31, Ill.

ARMY

Boston Ordnance Dist. Army Base, Boston 10, Mass.

Terminal guidance system, $99,990, **Sylvania Electric Products, Inc.**, 100 First Ave., Waltham, Mass.

Modified missile systems, $375,000, **Sylvania Electric Products, Inc.**, 100 First Ave., Waltham, Mass.

Cleveland Ordnance Dist., 1367 Sixth St., Cleveland 14, Ohio.

Research and development program

concerning feasibility of using magnesium-lithium base alloys in possible missile applications, $31,800, **Battelle Memorial Institute,** 505 King Ave., Columbus, Ohio.

Los Angeles Ordnance Dist., U. S. Army, 55 S. Grand Ave., Pasadena, Calif.

Nike repair parts, $67,711, **Douglas Aircraft Co.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Corporal ground guidance control equipment, amplifier, electronic control, $420,131, **Gilfillan Bros., Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Repair parts for Corporal missile system, $958,078, **Gilfillan Bros., Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Replenishment repair parts for guided missile, artillery M2 and related ground handling equipment, $147,591, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Dart. antitank guided missile, $1,325,000, **Aerophysics Development Corp.,** P.O. Box 689, Santa Barbara, Calif.

Nike repair parts, $136,750, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Material testing relative plasma jets, $105,243, **Giannini Research Corp.,** 18400 S. Main St., Santa Ana, Calif.

Propellant development, $232,955, **Grand Central Rocket Co.,** P.O. Box 111, Redlands, Calif.

Angle of attack transducers, $35,965, **Topp Industries, Inc.,** 5255 W. 102 St., Los Angeles 45, Calif.

Supplies and services for Honest John missile, $56,645, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Nike repair parts, $52,630, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Engineering services related to Corporal missile system, $195,660, **Gilfillan Bros., Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Target drones, $26,262, **Radioplane Co.,** 8000 Woodley Ave., Van Nuys, Calif.

Airborne digital computing techniques study, $44,557, **North American Aviation Inc.,** Autonetics Div., 9150 E. Imperial Highway, Downey, Calif.

Military Petroleum Supply Agency, Washington 25, D. C.

Jet fuel 5, $215,964, **The Texas Co.,** 135 E. 42 St., New York, N. Y.

U. S. Army Ordnance District, 55 South Grand Ave., Pasadena, Calif.

Corporal missile repair parts, kits and ground guidance control equipment, $1,423,082, **Gilfillan Bros., Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

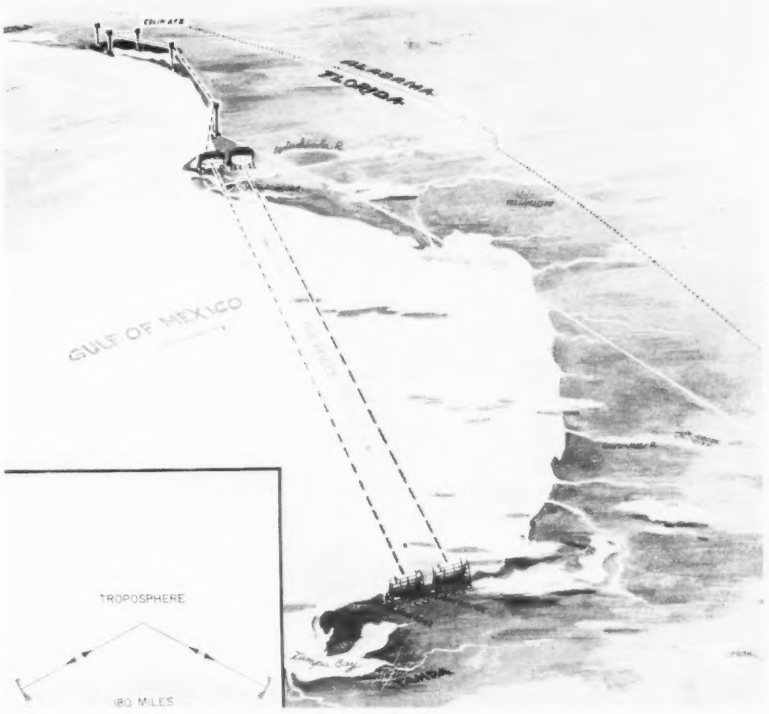
Missile research and development, $1,211,557, **North American Aviation, Inc.,** 6633 Canoga Ave., Canoga Park, Calif.

Additional research and development work connected with the Dart antitank guided missile system, $1,325,000, **Aerophysics Development Corp.,** Santa Barbara, Calif.

Nike repair parts, $270,448, **Douglas Aircraft Co.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Solid propellant research and development, $232,955, **Grand Central Rocket Co.,** Redlands, Calif.

AF Communications System to Span Gulf of Mexico



Radio signals are bounced off the earth's troposphere (insert) on the 180-mile span of this 295-mile communications system.

A 295-mile microwave relay and an over-the-horizon communications system that will span the Gulf of Mexico will be built for the Air Force Eglin Gulf Test Range, Fla., by Philco Corp.'s Government and Industrial Div. The system, to cost $2 million and be ready in 18 months, will be used for transmission of timing, telemetering, radar data and voice signal information along the Eglin range.

The first lap of the tandem system will be a 115-mile, five-hop, microwave relay, followed by the 180-mile, single-hop, tropospheric scatter system, which will extend from Cape San Blas to Anclote Point, near Tampa. Philco will put up two 60-ft parabolic antennas at each end of the 180-mile hop, capable of transmitting extremely high-power signals over the horizon. Over-the-horizon scatter hops are effected by reflecting radio signals off the earth's troposphere.

The microwave system will carry over 100 voice channels, but will be able to take 240 channels, if needed. Back-to-back terminals will be used at every station to provide independent circuits in each direction.

Missile supplies, $198,336, **Utility Metals Products,** 403 S. Raymond Ave., Pasadena, Calif.

Guided missile ground handling equipment and repair parts, $152,701, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles, Calif.

Missile experimental, developmental and research work, $105,243, **Giannini Research Corp.,** 18400 S. Main St., Santa Ana, Calif.

Target missiles training program, $26,262, **Radioplane Co.,** 8000 Woodley Ave., Van Nuys, Calif.

U. S. Army Signal Supply Agency, 225 S. Eighteenth St., Phila. 3, Pa.

Services for 24 mo. to conduct studies, investigations and evaluations in the field of combat surveillance, $1,476,400, **Cornell Aeronautical Lab.,** Buffalo, N. Y.

NAVY

Department of the Navy, Bureau of Aeronautics, Washington 25, D. C.

Technically trained employees to provide instruction in the maintenance, operation and servicing of liquid oxygen systems, $57,860, **Bendix Aviation Corp.,** (Pioneer Central Div.), Davenport, Iowa.

District Public Works Officer, Sixth Naval Dist., Bldg. 13, U. S. Naval Base, Charleston, S. C.

AF missile test center, offshore facilities, $1,455,000, **Pavarini Construction Co., Inc. and D. L. Prager and Co.,** 801 Second Ave., New York 17, N. Y.

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HARRISON, N. J.

Missile Market

(CONTINUED FROM PAGE 38)

peal for capital gains over the longer term." (Bache & Co.)

"For those who want to speculate in the missile field, *General Dynamics, Martin,* and *Thiokol* appear to be best buys." (Moody's)

Emerson Electric—"We feel that the issue, combining a strong participation in the missile program with a well-diversified industrial business in its fractional motors, offers appeal as a businessman's investment." (Pershing & Co.)

Chance Vought—" . . . the stock appears to us to have some speculative attraction based on the expected earnings increase." ($7–8 a share in 1958). (Hayden, Stone)

Financial Briefs

Emerson Electric equals last year's earnings in first quarter while backlog remains at $28 million, looks for improvement for balance of year . . . *North American Aviation* earnings drop to $0.81 per share for first quarter from $1.23 in previous year, puts backlog at $611 million . . . *General Precision Equipment's* dividend payments in 1957 are ruled tax-free by Internal Revenue Service . . . *General Dynamics* redeems its $3^1/_2$ per cent convertible debentures, due in 1975, at $105^1/_4$. This will leave the company as one of the few major defense contractors with little or no long-term debt . . . *Litton* reports first-quarter earnings up 44 per cent from previous year, backlog now at $54 million . . . *Lockheed* expects '58 sales to be 20 per cent in missiles, compared to only 8 per cent last year . . . *Tennessee Gas Transmission Co.* acquires 75 per cent interest in previously privately held *Grand Central Rocket Co.* for 60,000 shares of its own 5 per cent convertible preferred stock. Grand Central's sales in last fiscal year, ended July 31, 1957, totalled $5 million . . . *Thiokol* earned between $2.75 and $3 per share in 1957, as against $2 the previous year, estimates '58 earnings will increase a further 50 per cent . . . *Bendix Aviation* earns $5.44 per share in fiscal year ended September 30, up from $5.04 the previous year on fewer shares. Smaller sales volume expected in current fiscal year . . . *Douglas Aircraft* cuts extra dividend in half, expects lower '58 net earnings. Fiscal '57 profit declined to $8.28 a share from $8.96 despite increase in sales . . . *Raytheon* does not expect to pay any cash dividends in the foreseeable future, although stock dividends will probably continue.

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DATARITE magazine Type 5-047 attaches directly to the versatile 5-114 and Type 5-036 attaches directly to the 5-119 Recording Oscillograph without modifications or adapters. Magazines hold 400 ft. of thin-base recording paper. Record and event numbers are automatically imprinted for ease of data reduction. For complete DATARITE details contact your nearby CEC field office, or write for Bulletin CEC 1598-X14.

Descriptive literature on CEC's Recording Oscillographs: Type 5-114 (18 and 26-trace models, 7-inch record width) Bulletin CEC 1500-X22. Type 5-119 (36 and 50-trace models, 12-inch record width) Bulletin CEC 1536-X26.

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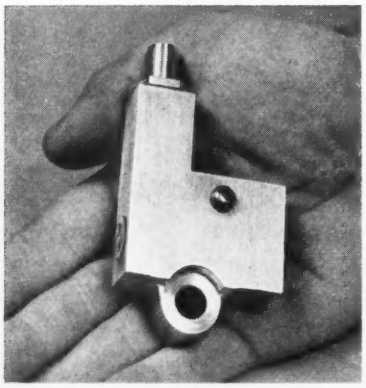


Uplock Actuator: In case of failure of the hydraulic or pneumatic system for actuating the landing gear, a miniature unit, weighing only 0.27 lb seals off the system and unlocks the gear. The unit initiates a solid propellant cartridge charge to supply gas to the uplock cylinder, allowing the gear to free-fall into position. It has been successfully tested on the F-101 Voodoo. Propellex Chemical Corp., Edwardsville, Ill.

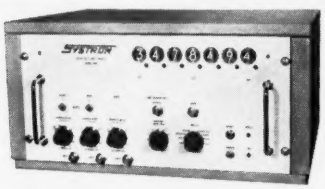
EQUIPMENT

Glass Domes: Servofrax arsenic trisulphide glass may be molded, ground and polished to produce one-piece domes. Used in transmitting infrared radiation to detection equipment, this shape is available in diameters from 4 to 12 in., and may be ordered in any spherical section up to and including 180 deg (hemisphere). Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

Variable Transformer: Model VT-1R5 transformer will deliver 1.5 amp at any brush setting, at full overvoltage. Brush arm carries no current, and a pigtail shunts the current from the brush to a copper graphite slip ring. The springlike brush arm provides its own independent contact pressure. A ceramic hub aligns and mounts the brush arm and provides 3000 volts ac insulation between parts at line potential and the shaft assembly. Ohmite Mfg. Co., 3667 Howard St., Skokie, Ill.

●

Infrared Protection: Irdomes protect the infrared detector and its optical elements against weather and other atmospheric hazards, yet are highly transparent to infrared energy in that portion of the spectrum for which the sensing or homing equipment was designed. Produced by a new quick method, they are available with spherical curvatures ranging from a slight meniscus to considerably more than a hemisphere, and in aspheric (nonspherical) shapes. Precision Lapping Co., Inc., 34 Clinton Ave., Valley Stream, L. I., N. Y.



Counter-Timer: The single package, in-line megacycle-microsecond Model 1031 counter-timer provides flexibility and reliability for laboratory applications. It measures frequency to 1 mc, time and period in 1 microsecond increments, phase angles in 0.1 deg increments, events to seven digits, ratio of two frequencies, and acts as a secondary frequency standard. Systron Corp., 2055 Concord Blvd., Concord, Calif.

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Teflon Rods: Tetrafluoroethylene resin rods are now produced in diameters from $^1/_{32}$ to 2 in. Within this range, rods can be supplied to the nearest 0.001 in. Sizes over 2 in. can be supplied in molded rod. Chemplast, Inc., 3 Central Ave., East Newark, N. J.

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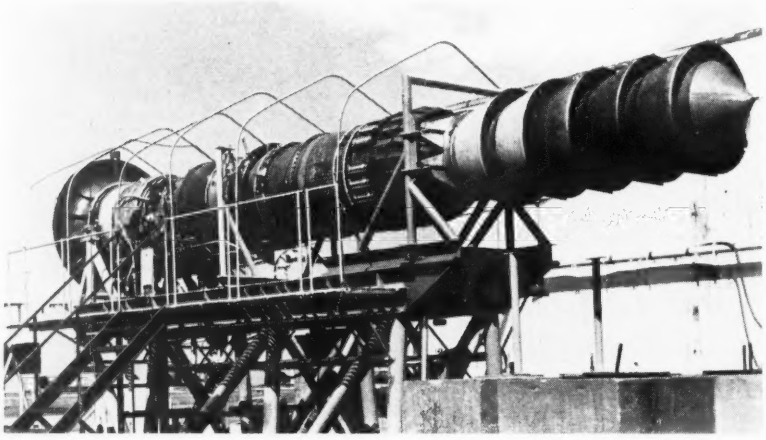
Tubeless Voltage Regulator: An all-purpose ac voltage regulator, the APR1010, can be used to regulate average and peak voltages independent of input waveform. By turning a switch, regulator output can be matched to special load requirements. Five different sensing arrangements are provided. Sorensen & Co., Inc., Richards Ave., S. Norwalk, Conn.



New Silencer for Jet Engines

This new lightweight jet engine exhaust noise suppressor on rear of the test stand is said to be the solution to ground run-up noise problems. Called Multi-Jet, the unit permits almost unlimited arrangement possibilities, and can be mounted on a trailer and handled by two men. A hinged adapter facilitates attachment to the jet engine. The unit, developed by Industrial Acoustics Co., New York City, has undergone successful evaluation tests at Republic Aviation's Farmingdale plant.

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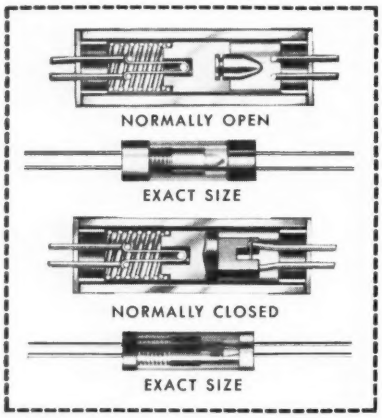

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On the Agenda: Two Major Space Flight Conferences

With interest in astronautics now at an all-time high, two major space flight conferences were announced last month. The Air Force Office of Scientific Research will hold its second annual Astronautics Symposium in Denver, Colo., April 28–30, while the AF School of Aviation Medicine will sponsor a four-day Space Flight Symposium in San Antonio, Tex., beginning Nov. 10.

The tentative program for the AFOSR symposium, co-sponsored by the Institute of the Aeronautical Sciences, calls for technical sessions the first two days and a field trip on the third day. Sessions will be devoted to space environment, vacuum chamber research, a report on Project Far Side, control and propulsion of vehicles, outside atmosphere, a panel discussion on the utilization of manned space operations, departure, space navigation and re-entry, and the earth's moon. A banquet is scheduled for the first evening of the symposium.

The first AFOSR symposium, co-sponsored by Convair-Astronautics, was held in February, 1957, in San Diego, Calif., and attracted an attendance of about 600. (March JET PROPULSION, p. 317, and April JP, p. 440.)

Some 40 scientists and test pilots working on problems of the upper atmosphere and space have been invited to present papers at the San Antonio conference, which will bring together top figures in the fields of astrophysics, chemistry and biology. The conference is being conducted by the Southwest Research Institute.

Co-chairmen of the meeting are Maj. Gen. Otis O. Benson Jr., commander of the AF School of Aviation Medicine, Randolph Field, Tex., and Hubertus Strughold, his research advisor. C. W. Smith, assistant to the president of the Southwest Research Institute, is conference secretary.

Papers will deal almost entirely with problems met within our own solar system, and since the conference is scheduled near the close of the present Geophysical Year, many of them are expected to reveal findings uncovered in the course of IGY research projects.

A similar symposium, held in the same city in 1951, dealt primarily with problems arising inside the aerodynamic limits of the atmosphere.

Jet Propulsion Looks to Future

(CONTINUED FROM PAGE 31)

supply of energy, however, the heat exchanger forms the basis for all nuclear-powered turbojet engine proposals.

With the turbine, major emphasis has again been on refinements aimed at increasing operating temperature and, hence, thermal efficiency. In an attempt to raise permissible blade temperature, for example, turbines are now air- or liquid-cooled, ceramic- or cermet-coated, etc. In addition, thrust augmentation devices, involving the use of alcohol or water injection, have been used to prevent overheating. However, all have decreased over-all operating efficiency.

The exhaust nozzle remained virtually unchanged up to the advent of variable area and, later, thrust reversing devices. Primary purpose of the "clam-shell" and "iris" variable area nozzles now in use is to provide efficient operation of the turbojet-afterburner combination, although they also improve turbojet operating efficiency. Further, at very high speeds the variable area nozzle is necessary even for the basic turbojet cycle to provide adequate range of operation from subsonic speeds up to Mach numbers approaching four.

The most popular thrust-reversers now under development use clam-shell plates which swing in from the nozzle exterior to block the exhaust stream, or Venetian-blind-type rings which, when open, protrude into the exhaust jet and deflect it forward. Thrust reversers, together with jet noise suppressors, are slated for early use on turbojet transports.

Although military applications favor the generally higher-thrust turbojet, the turboprop is rapidly finding a place of its own in the propulsion spectrum. It not only fills the range-speed gap between piston and turbojet aircraft, but also has a better thrust-to-weight ratio than the piston and lower specific fuel consumption than the turbojet. In addition, it operates more quietly than the turbojet due to its greatly reduced exhaust velocity, and its rotating motion largely frees it of the vibration problems which plague the piston engine. It thus appears quite promising for use on medium-range transports, and has proved quite successful on the Vickers Viscount airliners now in everyday use.

Hydrocarbon petroleum derivatives will probably continue to be the standard fuel for most air-breathing engines for some time to come. At the same time, certain high energy materials show considerable promise for high performance military aircraft. Based

on the light metals, such as lithium, aluminum and boron, these new fuels, either mixed with liquid hydrocarbons (slurries) or pure, provide considerably higher performance than even the best gasolines or standard jet fuels. Although their use presents some operational problems, the performance gain is so great that these so-called "chemical fuels" are likely to become operational shortly. Development studies utilizing diborane and boron hydride, for example, have been under way for several years.

The Ramjet

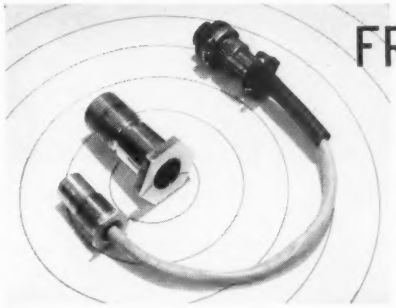
At higher speeds than can be handled by rotating compressors, the ordinary ramjet becomes a promising air-breathing powerplant. At Mach 4, for example, the theoretically obtainable combustion chamber pressure at sea level, due solely to the "ram" effect, is 2300 psi! Of course, this theoretical idea cannot be obtained in practice. In fact, few ramjets can operate below flight speeds of 400 or 500 mph because of aerodynamic losses.

To date, much ramjet work has been concerned with development of efficient diffusers unaffected by flight characteristics such as changes in flight speed, angle of attack or yaw, altitude and fuel flow. Although this work is still far from complete, the modern spike diffuser with variable inlet area has made supersonic ramjet operation possible, if not efficient.

The second major bar to ramjet development has been the combustion chamber. Adequate mixing and "flame-holding" are far more difficult to achieve in the ramjet because it has a much higher internal air speed as compared to the turbojet. The grill-type flameholder which appeared in the first low-speed ramjets has been almost completely replaced by the perforated-sheet annual or cannular flameholders, which, however introduce larger losses due to turbulence. In addition to the basic difficulty of preventing flame blowout, the high heat release rates of ramjets often lead to combustion instability, phenomenon which may cause serious damage to engine components. And, finally, the possible application of nuclear-powered heat exchangers makes the need for efficient ramjet "combustion chamber" design all the more important.

The nature of the ramjet operational cycle, heavily dependent on the manner in which air flows at high speeds through a shaped duct, has introduced a third difficulty in ramjet development—the control system. Interdependence of engine component operation requires fuel controls that

do you have these missile power problems?



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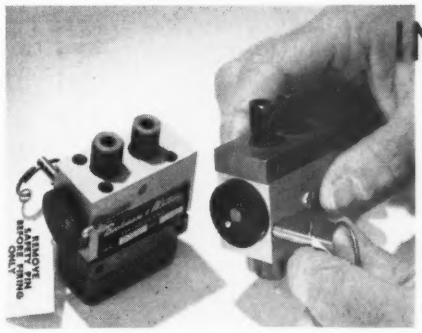

INITIATION?

Same basic mechanism serves, right, as a detonator-safe primacord initiator, having a lanyard-operated safety pin; or, by the substitution of an explosive charge, bottom left, unit becomes a destructor. Two separate channels for top reliability, mechanism so designed that re-insertion of safety pin reverses unit from "arm" to "safe" position. If these sound too simple, we can show you some *complicated* ones.

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ABMA Sets Up Planning Office

Members of the new Army Ballistic Missile Agency planning office, which will plan and control long-range missile and rocket programs, are (l to r): Lt. Col. E. M. Graham, executive secretary; Col. J. G. Zierdt; Col. H. S. Newhall, Commander, Ordnance Guided Missile School; Maj. Gen. J. B. Medaris, chief of the office and Commander, ABMA; Maj. Gen. H. N. Toftoy, Commander, Redstone Arsenal; Col. H. N. Brownson; and Maj. W. B. Hawkins.

can react quickly and accurately to variations in a number of engine characteristics. Although several specific ramjet control systems are already in operation, this problem also remains for the most part unsolved.

The Rocket

The primary disadvantage of the rocket engine in aircraft propulsion lies in its tremendous propellant consumption rate. Since it cannot utilize the "free" air which forms over 90 per cent of the working fluid of air-breathing engines, it must carry its own oxidant, as well as fuel. But, by the same token, since chamber pressure, and hence thrust, do not depend on compression of atmospheric air, very high chamber pressures can be used. This gives the rocket the highest thrust-to-weight ratio of all aircraft powerplants.

The solid propellant rocket, in most cases simple and inexpensive compared to the liquid rocket, is used almost exclusively for armament rockets, assisted take-off applications and boosters. However, recent developments in propellant chemistry and grain design have improved overall performance of solid rockets to such an extent that they have taken over many liquid applications in sounding rockets, medium- and long-range missiles, and even in satellite vehicles. (The third stage of Vanguard, for example, is a solid rocket.)

The main advantage of the solid rocket, other than cost and simplicity, is the high mass ratio obtainable, since the only "dead weight" in the propulsion system is the chamber casing and nozzle. Its principal disadvantage is its present inability to be stopped, restarted or throttled. Although solids cannot yet compete with liquid rockets in these respects, there have been recent indications that the problem of major interest in ballistic missiles—accurate cutoff of thrust—has been solved. Another former disadvantage of solid rockets, the generally short duration, has also been eliminated, with operational burning times now going as high as 7 min (e.g., the Phillips engine which powers the new Radioplane target drone).

One further disadvantage of the solid rocket is that its excessive length prevents convenient gimballing for directional thrust control. Recent advances in "jetevators" (control vanes in the rocket exhaust), however, could lead to complete directional control for even the largest solid rockets.

In contrast to the simplicity of most solid rockets, the liquid propellant rocket must use a relatively involved propellant feed system, but in many cases its higher performance and controllability outweigh the disadvantages of system complexity. The liquid engine is still the mainstay of guided missile propulsion, and holds exclusive sway in the propulsion of piloted rocket aircraft. Further, the higher specific impulses apparently obtainable with some of the newer chemical fuels will give the liquid rocket an additional advantage over the solid rocket.

Principal developments in the field of liquid propellant rockets, other than the continued refinement of the combustion chambers and system components, have been in the propellants themselves. Although the old standbys, such as liquid oxygen, nitric acid, and hydrogen peroxide used with jet fuels and alcohol, still power the bulk of operational and developmental engines, the new "exotic" propellants now under evaluation offer improvements in performance significant enough in most instances to offset the additional hazards involved in handling them. Among the propellants now being evaluated on actual rocket development programs are liquid fluorine and its compounds and liquid ozone for oxidizers, and liquid hydrogen, the metallic hydrides, various form of hydrazine, cyanogens, "slurries," and hydrocarbons with high percentages of hydrogen for fuels.

The maximum specific impulse obtainable from direct chemical reactions lies in the upper 300's. To achieve a significant jump in performance, it is necessary to leave the domain of straightforward combustion chemistry and move into less well-known fields. Before beginning this "blue sky" discussion, however, it might be well to digress first to some of the existing class of engines known as "hybrids."

"Hybrid" Engines

Hybrid engines date back as far as World War I, when engineers added a turbine-driven compressor to a reciprocating powerplant to recover some of the exhaust gas energy. This principle has grown from the ordinary supercharger into the most modern high-powered piston powerplant, the turbo-compound engine.

The first major gap in the propulsion spectrum shown on page 29 lies between the turbojet and ramjet. Part of this gap has been filled by the turbojet with afterburner, which combines the two basic engine types directly. Since turbojet combustion chamber temperature is limited by turbine blading material, another combustion chamber is added downstream of the turbine, permitting utilization of much higher gas temperatures and thus greatly increasing the thrust obtainable from a given flow of air. Although less efficient than the pure turbojet, the afterburner is used on all modern military aircraft for take-off and high-speed maneuvers, since it can provide up to 100 per cent thrust increases over the basic engine.

A sophisticated modification of the afterburning turbojet appears in the "dual cycle" engine. This is basically an afterburning turbojet equipped with the necessary valves and ducting to block off the turbojet portion completely, allowing the engine to operate as a pure ramjet at high speeds. This promising configuration saw extensive development at Curtiss-Wright

until recent cancellation of the prime airframe contract brought it to a halt.

A second application of the afterburning principle appears in the turborocket, a hybrid derived from the turbojet and rocket powerplants. Here the turbine is driven by the exhaust from a number of rocket engines operating either heavily fuel rich or with a monopropellant, so that the major part of combustion occurs when the hot, fuel-rich rocket exhaust gases encounter the compressed air downstream of the turbine. Additional fuel may also be introduced at this point, as in the case of the afterburner. Although the turborocket has not yet been used operationally, it shows promise for some special-purpose aircraft.

For speeds beyond those which can be efficiently handled by rotating compressors, engineers are considering the ram rocket, or ducted rocket, which combines the ramjet and rocket engines. This powerplant consists of one or more rockets mounted inside the ramjet, so that the highly fuel-rich or monopropellant rockets act as both igniters and fuel injectors for the ramjet. As in the turborocket, secondary fuel injection would also be used. The rocket augments the ramjet thrust both by direct rocket thrust and entrainment of more air than the simple ramjet can handle, and also provides static thrust, so that, unlike the ramjet, the ramrocket can start from rest.

To combine the controllability of liquid rockets with the high mass ratio and simplicity of solid rockets, a hybrid using a liquid oxidizer and a solid fuel grain in the combustion chamber has been suggested. Although a complete feed system for one liquid propellant is still required, performance of the hybrid rocket can be improved substantially over that of any monopropellant type. One propellant combination under evaluation, using hydrogen peroxide oxidizer and solid polyethylene fuel, shows a great deal of promise.

Nonconventional Rockets

Returning now to our discussion of nonconventional rocket powerplants, the necessity for their consideration lies in the fact, stated earlier, that the maximum specific impulse obtainable from direct chemical reactions lies in the upper 300's. A first attempt to breach this barrier may lie in possible exploitation of the energy of the bonds which hold atoms, or groups of atoms called radicals, together as molecules. When certain chemical compounds are separated into their constituent radicals, they recombine with the release of enormous amounts of heat. If some method could be found for separating

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and storing these radicals and introducing them into a rocket engine, they would, upon recombination into molecules, provide theoretical specific impulses well over 1500 sec in some cases.

The most promising major advance in rocket technology at the present time, however, appears to lie in the realm of nuclear power. Unfortunately, serious obstacles must be overcome before this power source can be effectively realized. The application of nuclear energy to air-breathing engines is theoretically a straightforward problem, although some of the practical aspects (e.g., proper shielding) may become difficult. The basic advantage of air-breathing nuclear powerplants lies in the availability of both practically unlimited energy and unlimited quantities of the working fluid-air. This combination permits successful application of engine cycles with rather low thermal efficiency.

Fluid Is Carried Aboard

However, in the case of the rocket, although the same energy is available from the nuclear power source, the working fluid necessary for propulsion must be carried aboard. Thus high cycle efficiencies are essential to successful performance of a nuclear rocket.

Rocket "efficiency" is best determined in terms of specific impulse, which is given by the exhaust gas velocity. Since this is proportional to the square root of the working fluid stagnation temperature, the requirement of high specific impulse is equivalent to that of high working fluid temperatures. If we consider the best of the ordinary "nuclear furnace" powerplants, in which a porous matrix of fissionable material heats a propellant gas by direct contact, we find that matrix material limitations impose temperature restrictions at a considerably lower level than those produced by the best chemical fuels burning in a cooled chamber.

Of course, since the specific impulse also decreases with the square root of the molecular weight of the working fluid, it is possible to exceed over-all chemical rocket performance by using working fluids of low molecular weight. Despite this benefit, the best performance of solid-core "nuclear furnace" rockets is limited by temperature to the order of twice that of the best chemical fuels. This might be enough to make very large nuclear rockets better than very large chemical rockets, but the weight of the reactor and its shielding imposes a penalty which, despite its superior performance, makes even the best basic "furnace" type of nuclear rocket only slightly better than the best chemical rockets in, say, the IRBM-ICBM size range. A considerable effort to determine the practical feasibility of this class of nuclear rocket is currently under way.

To extend nuclear rocket performance to the point at which its clear supremacy is established, nonconventional reactors must be employed. Some thought has been given to the simple method of increasing reactor temperatures by using molten uranium cores or even cores utilizing gaseous uranium compounds. Although these obviously require considerable extrapolation of existing reactor technology, there may be considerable promise in the idea.

Other groups have considered the nuclear-chemical hybrid. One simple example of this would be a cycle using a combustible fuel which is first heated in a more or less conventional nuclear reactor and then oxidized chemically to raise its temperature to a point which would be beyond the tolerance of the reactor. Although at first such hybrids look quite good, the disadvantages lie in the fact that first, there is a finite limit to the ultimate combustion temperatures attainable, and second, the molecular weight of the exhaust gases would usually be considerably higher than that of the gases which may be used in a straight nuclear rocket.

A great improvement in pure nuclear rocket efficiency might be obtained if it were possible to direct the flow of the nuclear fission fragments themselves, or, in the case of the controlled thermonuclear reactor, the products of the fusion reaction. Specific impulses for these types of rocket powerplants might range up in the millions of seconds, since particle velocities are so high. However, the problem of converting the high-energy random particle motion occuring within a reactor into directed mass flow, if possible at all, would require enormous auxiliary components. Hence this type of powerplant must await development of a whole new technology, and, possibly, a new science.

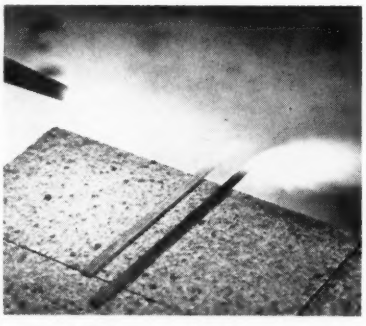
The problem of achieving extreme particle velocities can be solved in a comparatively simple manner, however, by the "ion rocket." Here, instead of attempting to control the flow of nuclear reaction products directly, the reactor is used simply as a conventional electrical power source to provide a high voltage across a set of electrodes. The working fluid is ionized with heat supplied by the reactor, and the resulting ions and electrons are accelerated to extreme velocities by the electric field. The configuration of the ionization chamber and electrodes can easily be devised so that both electrons and ions are ejected in the same direction, providing the momentum required to produce thrust.

Ion Rocket Limited

Although specific impulses in the millions of seconds can be obtained this way, the power required to ionize and accelerate a very large number of atoms by this very inefficient nuclear-to-heat, plus nuclear-to-heat-to-electrical, energy conversion process is enormous. Hence, the ion rocket, although capable of the high particle exhaust velocities which can produce extremely high specific impulses, is limited to quite low thrust levels, of the order of several pounds, at most. Working models of ion rockets, utilizing commercial electrical equipment instead of the nuclear power source, have been exhibited, and several contracts to explore the practicality of this powerplant have been in existence for some time.

The ultimate propulsion efficiency obtainable from the momentum principle of reaction powerplants will obviously occur when the working "fluid" is exhausted from a rocket at the speed of light. Since it appears from the arguments of the relativity theory that

Molybdenum Weathers High Heat Treatment



Under 2600 F, molybdenum treated by Chromalloy W-2 process does not fall apart, while untreated bar can be seen eroding.

A new surface alloying technique now makes it possible to use molybdenum at working temperatures in excess of 2000 F. The new technique, developed by Chromalloy Corp., and called Chromalloy W-2 process, provides molybdenum with a high degree of oxidation resistance. Until now, it has been impossible to take advantage of molybdenum's outstanding high-temperature strength because it formed a volatile oxide which led to rapid erosion at high temperatures.

particles of finite mass can never reach this speed, it was first proposed by Sänger to utilize photons—popularly described as "packets of energy" traveling at the speed of light. Ordinary visible light is composed of rather low-energy photons, and hence it is extremely difficult to measure the momentum or pressure produced by the photons of ordinary light.

Einstein Theory

It may seem strange to speak of the momentum of a particle having no mass, but it must be remembered that, in terms of the equivalence of mass and energy first stated by Einstein, a photon's energy may be considered as an equivalent mass. In the case of the low-energy photons in visible light, this equivalent mass is tiny. It nevertheless exists, as is demonstrated most graphically by the behavior of the tenuous gases in a comet's tail, which are pushed away from the sun by the "pressure" of the sun's radiated energy.

If, now, it were possible to obtain a directed flow of extremely high energy photons, we would have our "ideal" reaction engine. Although both fission and fusion reactors are excellent sources of high energy photons, the problem of "lining-up" their random directions of motion, as in the nuclear fragment idea, becomes insurmountable under existing technology or any of its extrapolations. (Remember that, although ordinary light is easily directed by mirrors, we have no known method of redirecting the high energy photons which comprise the gamma radiation from nuclear processes.) Further, even though specific impulses as high as 10^{10} sec have been quoted for photon rockets, their thrust level will be lower by several orders of magnitude than that of even an ion rocket of comparable power.

Hence, these last two "blue-sky" powerplants, which have thrust-to-weight ratios far less than unity, would be useful only for regions in which gravitational fields are negligible.

The foregoing discussion has been based on what is currently known about the phenomena of nature. However, it is not inconceivable that future scientific discoveries may open entirely new realms in the field of propulsion. The best current example of this type is the intensive, although as yet apparently unrewarding, work now being conducted by The Martin Co. and other research groups on the principles leading to possible manipulation of gravitic fields, popularly but improperly labeled "antigravity."

It is perhaps in this, or in some currently inconceivable field of study, that future propulsion systems may ultimately be found.

11-30

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NACA Urges National Space Flight Research Program

The National Advisory Committee for Aeronautics has called for an "adequate" national research program for space technology in a resolution issued at the same time as its annual report.

The resolution calls for enlistment of the nation's scientific and engineering resources in a program which would include:

1. Research in space technology to provide data for the design of vehicles and to assure the success of manned space flight operations.

2. Design and development of scientific and military space vehicles and their launching, flight and recovery.

3. Research on phenomena of the high upper atmosphere and nearby space, and scientific studies of the universe from satellites and space platforms.

The program would be a cooperative effort of the Department of Defense, NACA, National Academy of Sciences and National Science Foundation, as well as universities, research institutions and industry. Military vehicles are regarded as the function of DOD, but additional vehicles and operations needed for scientific purposes would fall within the purview of the NACA or become joint DOD-NACA projects. Scientific planning would be a function of NSF-NAS, with NSF assuming financial responsibility. NACA would also function as a coordinating agency and would expand existing facilities in this area or add supplementary facilities.

The resolution, based on an NACA staff study, did not recommend that any specific sum be appropriated for such a program.

In an address on "Space Technology and the NACA" delivered at the Institute of Aeronautical Sciences annual meeting in New York City, Hugh L. Dryden, NACA director, revealed the make-up of the recently appointed NACA Special Committee on Space Technology. The committee, chaired by H. Guyford Stever, associate dean of engineering at MIT, includes:

H. Julian Allen, Ames Aeronautical Laboratory; Hendrik W. Bode, Bell Telephone Laboratories; Milton U. Clauser, Ramo-Wooldridge Corp.; Dale R. Corson, Cornell University; James R. Dempsey, Convair-Astronautics; Robert R. Gilruth, Langley Aeronautical Laboratory; S. K. Hoffman, Rocketdyne; William H. Pickering, Jet Propulsion Laboratory, California Institute of Technology; Louis N. Ridenour Jr., Lockheed Missile Systems Div.; Abe Silverstein, Lewis Flight Propulsion Laboratory; James A. Van Allen, State University of Iowa; and Wernher von Braun, Army Ballistic Missile Agency.

The main element of scientific interest in the NACA annual report was the description of the atmosphere entry simulator designed by Alfred J. Eggers Jr. of Ames Aeronautical Laboratory, which allows study of re-entry problems on the ground.

NACA calculates that a model only 0.36 in. in diam and weighing only 0.005 lb can simulate re-entry flight of a full-scale 4000-mi range missile 3 ft in diam and weighing 5000 lb through use of the simulator.

Main element of the simulator is a trumpet-shaped nozzle through which air at supersonic speeds undergoes changes in density from one end of a 20-ft passage to the other. Missile models are launched from a high velocity gun against the air stream and encounter air of increasing density in flight. The simulator can provide a variation in density over a range of 100,000 ft and is used at altitudes up to a maximum of 200,000 ft.

A working pilot model is already in use at Ames, while a larger version is nearing completion. NACA says the simulator will be in operation later this year.

The report, written in nontechnical language for the first time, also includes a complete listing of 1957 NACA reports and papers, as well as a rundown on the agency's organization and operations.

It also contains a lengthy description of research in high-energy fuels, conducted at Lewis Flight Propulsion Laboratory, as well as reports on research work in hypersonic speeds, flight testing of multistage rockets of various types, and studies in high-temperature testing of missile and aircraft materials and components.

Astro Report—AFCRC

(CONTINUED FROM PAGE 37)

whole. The Programs Branch, as its name implies, formulates, establishes and reviews all programs with an eye to AF requirements. It also allocates resources within the directorate and acts as liaison between the directorate and other government agencies or scientific organizations.

Applications and Logistics is concerned with administration of the directorate. It handles personnel, arranges field projects and provides staff engineering services. At the other end of the line, it is responsible "for maximum application by the Air Force of the R&D products of the directorate," as well as for the nature and quality of GRD reports, or "written products."

A third group, the Special Projects Laboratory, although not a staff section, does service many of the other laboratories as part of its mission. Under the direction of Elbert Eaton, SPL is responsible for developing vehicles and instrumentation for investigation of the atmosphere and space.

In this work, Eaton's lieutenants are Robert Slavin, Lou Kraff and Charles Reynolds. Their job is first to get the vehicle, and then to instrument it, set up ground stations, and, if necessary, to try to recover the vehicle. Their philosophy is to work as far as possible with existing components, particularly in the development of research vehicles.

Using off-the-shelf items, Eaton and his group feel they can get more vehicles into the air in less time for the same amount of money it would take to develop new systems. As an example of this, they cite their new solid propellant rocket, Exos, which they believe they can put into the air for about $17,000 (December, 1957, ASTRONAUTICS, page 28).

A new section within SPL is Atmospheric Nuclear Chemistry, which handles research on sensitive radiochemical measurement techniques and the monitoring and measurement of nuclear radiation in the atmosphere.

The Aerosol Physics Laboratory, under Peter Wyckoff, is concerned with the effects produced by natural and foreign matter suspended in the atmosphere.

Most of APL's work takes place in the region below 100,000 ft because this is where most of the aerosols are found. At present, the lab relies principally upon balloons for its research vehicles. Some day, says Wyckoff, they will go to rockets, "but there's still so much to learn in the lower regions."

There's atmospheric dust, for example. What is it? Where does it come from? Such questions are no longer mere curiosity teasers. Today, this dust is an important factor in space flight. It erodes, punctures, obfuscates, creates drag and who knows what else.

Then there is the problem of contrails created by jet exhausts. This finger in the sky, as Wyckoff describes it, is a dead giveaway of a plane's position. "We know what contrails are and how they're caused," says Wyckoff. "The problem now is to eliminate them."

Poor visibility at high altitudes is another problem Wyckoff's team is concerned with. At 50,000 ft, for instance, there are few particles to scatter light, so that, when light strikes an object at this height, it is reflected poorly. One consequence of this is that two jet fighters on a high-altitude collision course will not be able to see each other in time to avoid a crash.

This problem of visibility, of course, is also of prime importance to missile tracking. One group from APL has been working at Patrick AFB trying to correlate visibility parameters with meteorological parameters so as to predict optical tracking conditions for the missile men and their cameras.

The work at APL has its "un-practical" side, too. One program for example, is devoted to the charging mechanism of the thunderstorm. Others study the relationship of meteoric dust to rainfall; the mechanics of cloud formation; carbon dioxide concentration at different atmospheric levels; etc.

Ideally, Wyckoff's group would like to control the weather, at least on a small local scale. But, until this can be done, the Air Force will have to rely on its meteorologists—not to control the weather, but to predict it. And right now, even prediction isn't very reliable. Small wonder, too, one meteorologist says, when you consider that forecasting techniques are essentially the same now as they were 100 years ago.

More Reliable Techniques

The Atmospheric Analysis Laboratory, however, plans to change all this. Using everything from old weather records to airborne digital computers, AAL hopes to make weather forecasting more of a science and less of an art. The approach is twofold: (1) To improve forecasting from available data by making use of new numerical methods and computers; and (2) to learn more about the actual hydrodynamics of the atmosphere, and, from this new knowledge, to develop improved forecasting techniques.

The mission of the Thermal Radiation Laboratory is research on infrared radiative transfer and high-temperature weapon phenomenology.

One group investigates all waves emitted by hot bodies. Another is concerned with the development of

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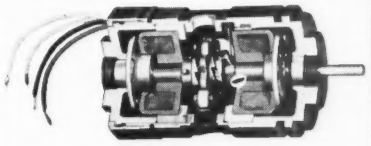

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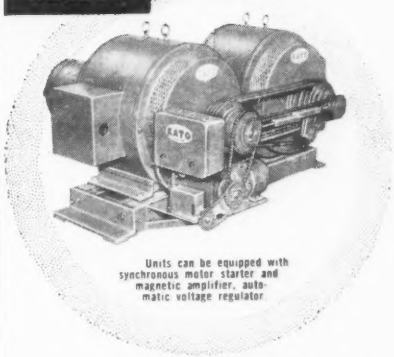

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more knowledge about such infrared phenomena as spectral emission, absorption, reflection and attenuation.

The high temperature section of the lab is involved in the physics of weapon phenomenology. An outgrowth of nuclear weapon work, projects in this area cover such things as thermal radiation and blast, high Mach shocks and magneto hydrodynamics. Among other things, the scientists study the effects produced by a missile in this atmosphere and environment with a view to predicting what effects will be produced in other atmospheres and environments.

The other two sections in this group are thermal test, an actual field test group, and thermal spectroscopy. The latter studies the high-speed optical behavior of weapon phenomenology.

Ionization from the ground up is the special province of the Ionospheric Physics Laboratory. Much of the work in this section is basic in that it simply seeks to understand (1) what really happens in ionized regions and (2) why. However, in answering these questions, IPL comes up with information that has a great deal of practical value for communications and navigation, and more specifically, missile guidance.

Ionospheric characteristics, one of the three IPL sections, studies the physical characteristics of the ionized layers and theories of their formation. Like its Naval Research Laboratory counterpart, this group uses high altitude sounding rockets to measure such things as ion density. Techniques, however, are different, and serve to check one another.

The auroral physics section tries to pinpoint constituents of the atmosphere from about 60 to 600 miles up. The scientists carry out spectroscopic investigations of the auroras and their relation to high atmosphere problems, particularly in the polar regions.

Geomagnetics, the third group, studies variations of the earth's magnetic field and the relationship of these variations to navigation and communication problems. IPL is interested in the variations because their origin lies in the ionosphere.

The earth is still the point of origin and termination of all aircraft flight, and that, according to James Peoples Jr., is the reason for AFCRC's Terrestrial Sciences Laboratory.

Surface studies, for example, occupy a prominent place in Dr. Peoples' research program. Operating in and over areas where there are no air fields, the Air Force often wants to know if the ground will support emergency landings, permanent air strips, heavy fuel trucks, etc. The Arctic in particular is a major problem area.

The Terrestrial Sciences Lab has solved some of these problems and is on the way to solving others. In one series of experiments, for example, the group showed that certain kinds of sea ice made an excellent runway, could be prepared in only a fraction of the time needed for a standard field, would support heavy aircraft, and was not noticeably damaged by jet exhausts. The lab also developed an aerial penetrometer to determine soil strength.

Long Arm of Research

But the responsibility of this lab does not stop at surface investigations. Rather, its research interests extend from the earth's interior out to the atmosphere. Among other things, it is investigating the earth's permanent magnetic field and is working on the development of more precise techniques for making geodetic measurements. Both of these studies are expected to make major contributions to the development and operation of missiles.

The Advanced Research Laboratory, under Marcus O'Day, conducts "special advanced investigations in the frontiers of geophysical research."

This mission, in effect, gives Dr. O'Day almost all the world's unknowns to work with. From this tempting scientific array, Dr. O'Day has selected some rather challenging projects. One is the containment of a gas by means of a strong electromagnetic field. This is part of the lab's work in plasma physics.

Another area under investigation involves geophysical energy sources. One example is the study of a thermocouple technique for making use of the large permanent vertical temperature gradients in the oceans. Whether or not some practical means of doing this can be found is secondary to Dr. O'Day. His primary interest is the development of more information for the sake of increasing knowledge, not for heating homes.

In October, 1955, a group of scientists under lab chief Murray Zelikoff carried out the first of the experiments in the creation of artificial "starlight" for which the Photochemistry Lab has best become known.

One of the last experiments in this series, in which 20 lb of sodium vapor was released from a balloon in the ozone layer at 88,000 ft, actually created enough light to cast shadows on the ground. Ten times brighter than Venus in intensity, the light lasted five minutes and was visible for 400 miles.

Some day, says Dr. Zelikoff, it may be possible to light entire cities using similar measures. But the creation of artificial light was only incidental to the experiment, he points out. The principal purpose of these studies was to show that energy from the sun was stored in the atmosphere in the form of ions, radicals and free atoms, and that the release of this energy can be accelerated by the introduction of a catalyst into the region.

Today, experiments have demonstrated the presence of free atoms of oxygen and nitrogen in the atmosphere. The lab plans to continue the experiments in an attempt to find and release light from atomic hydrogen and hydroxyl radicals. An interesting sidelight to the work is the development of a monatomic ramjet to make use of this free energy (December, 1957, ASTRONAUTICS, page 28).

Less well known, but even more vital, perhaps, is the work the lab is

Radome Testing

Up to 18 radomes can be tested simultaneously from this newly built three-story master control center with its six radially dispersed testing towers. Zenith Plastics Co., Gardena, Calif., constructed the facility for pretesting plastic radomes, and plans to make the plant available on an industry-wide rental basis.

Moonwatch Group Gets Oscillograph

Recording oscillograph (center foreground) that will help in tracking satellites has been loaned to the amateur tracking station of the San Gabriel Valley (Calif.) Radio Club by Consolidated Electrodynamics Corp. Richard Major, CEC application engineer (right), explains the role of cigarette-size galvanometers which form the heart of the oscillograph to Henry L. Richter of the California Institute of Technology, who heads the station.

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doing in the development of design criteria for high altitude and space vehicles. From their studies of the composition of the atmosphere, lab scientists are able to supply designers with information on temperature, density, micrometeorites, radiation, etc., that the vehicles might encounter at different altitudes.

Concerned primarily with the development of plastic balloons, the Atmospheric Devices Lab is headed by an Air Force officer, Maj. Richard Braun.

Balloon Experiments

Most of its own balloon work, says Maj. Braun, is classified. An exception is the Nielson Project. This will consist of three balloon flights in which a parachutist will jump from a gondola, first at 60,000 ft, next at 75,000 ft, and in the third flight, from 90,000 ft.

ADL's responsibility includes development and testing of atmospheric devices designed to solve AF operational problems. This includes such things as the over-all system of which the balloon is a part, supporting electronic gear, launching techniques, as well as other equipment not necessarily a part of balloon work, such as meteorological gear and sensing elements.

In addition to balloon-borne devices, the laboratory develops ground-leased meteorological observing, recording and transmitting devices and systems for the Air Force.

At Sacramento Peak Observatory, located at Sunspot, N. M., scientists under the supervision of John Evans, study the sun with an eye to the effects solar phenomena produce in the terrestrial atmosphere. More specifically, their goal is: (1) To obtain extremely accurate and detailed solar data; (2) to relate this data to known atmospheric activities; and (3) to develop theories to explain these activities in light of the available data.

But the work at Sunspot is not merely academic. One aim of this group, according to Dr. Evans, is the development of data and theories that could play an important role in the improvement of long-distance communication.

° ° °

Next month, ASTRONAUTICS *will present the second part of this report on the Air Force Cambridge Research Center. Part II will cover the mission, organization and work of the Electronics Research Directorate, as well as the nonresearch, supporting groups which are essential to the smooth, integrated operation of AFCRC.*

Novel Launching

NEW I C B M LAUNCHED

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Total Wt.	-	5 lbs. 14.5 oz.
Fuel System	-	Externally Fed

Test Results:

Airframe	-	Preliminary Checkout - O. K.
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Powerplant	-	Pre-Flight Tests Satisfactory
Noise Level	-	2 DB

Development Contractors — Annie & Rod Stewart

Launching Contractor — Dr. D. B. Reynolds

Nomenclature — Robert Douglas Stewart

Launching Time — 12:25 p. m. - 25 Jan. 58

Birth announcement sent out by ARS member Rod Stewart, Thiokol Chemical Co., Huntsville, Ala., spotlighting a new kind of "ICBM."

Index to Advertisers

American Potash and Chemical Corporation 77
The McCarty Co., Los Angeles, Calif.

The Annin Company 39
The McCarty Co., Los Angeles, Calif.

Beckman & Whitley, Incorporated 79
Gerth-Pacific Advertising Agency, San Francisco, Calif.

Cannon Electric Company 12–13
Willard G. Gregory & Co., Los Angeles, Calif.

Cardox Corporation 43
Stoetzel & Associates, Inc., Chicago, Ill.

Consolidated Electrodynamics Corporation 4, 42, 75
Hixson & Jorgensen, Inc., Los Angeles, Calif.

Control Products, Inc. 74
Reid, Decker & Stocki, Inc., Newark, N. J.

Convair, A Division of General Dynamics Corporation ..... Back Cover
Buchanan & Company, Inc., Los Angeles, Calif.

J. H. Day Company 47
The Keelor & Stites Company, Cincinnati, Ohio

Decker Aviation Corporation 61
The Harry P. Bridge Company, Philadelphia, Pa.

Diversey Engineering Corporation 11
Roark and Colby Advertising, Chicago, Ill.

The Dow Chemical Company 51
MacManus, John & Adams, Inc., Bloomfield Hills, Mich.

General Electric Company, Missile Guidance Product Section 69
Deutsch & Shea, Inc., New York, N. Y.

Grand Central Rocket Company ..... Second Cover
Byron H. Brown and Staff, Inc., Beverely Hills, Calif.

Interelectronics, Inc. 71
Corbin Advertising Agency, New York, N. Y.

Kato Engineering Company 85
Frizzell Advertising Agency, Inc., Minneapolis, Minn.

Librascope, Incorporated 1
Compton Advertising, Inc., Los Angeles, Calif.

Marquardt Aircraft Company ..... 88, Third Cover
Grant Advertising, Inc., Hollywood, Calif.

The Martin Company 40–41
Van Sant, Dugdale & Company, Inc., Baltimore, Md.

Menasco Manufacturing Company 16
The McCarty Co., Los Angeles, Calif

Minneapolis-Honeywell Regulator Co. 64–65
Foote, Cone & Belding, Chicago, Ill.

Networks Electronics Corporation 78
The McCarty Co., Los Angeles, Calif.

New Departure, Division of General Motors Corporation 59
D. P. Brother & Co., Detroit, Mich.

Phillips Control Corporation 48A–49A
Kenneth B. Butler & Associates, Mendota, Ill.

Radio Corporation of America 67
Al Paul Lefton Co., Inc., Philadelphia, Pa.

Ramo-Wooldridge Corporation, Space Technology Laboratories 2
The McCarty Co., Los Angeles, Calif.

Rez-Coat, Division of H. I. Thompson Fiber Glass Company 14
Van der Boom, Hunt, McNaughton, Inc., Los Angeles, Calif.

Southwest Products Company 87
O. K. Fagan Advertising Agency, Los Angeles, Calif.

Special Projects Branch, Food Machinery & Chemical Corporation 85

Sperry Gyroscope Company, Division of The Sperry Rand Corporation 9
Reach, McClinton & Co., Inc., Newark, N. J.

Stepper Motors, Operated as a Division of Land-Air, Inc. 85
The Admaster Associates, Barrington, Ill.

Sundstrand Aviation, Division Rockford, Illinois 57
Howard H. Monk & Associates, Inc., Rockford, Ill.

Sun Electric Corporation 7
N. E. Anson, Lake Zurich, Ill.

System Development Corporation 83
Stromberger, LaVene, McKenzie, Los Angeles, Calif.

Thiokol Chemical Corporation 45
Dancer-Fitzgerald-Sample, Inc., New York, N. Y.

H. I. Thompson Fiber Glass Company 15
Van der Boom, Hunt, McNaughton, Inc., Los Angeles, Calif.

Val-Aero, a Division of Darco Industries 48
Lester-Voorhees Company, Los Angeles, Calif.

D. Van Nostrand Company, Inc. 81
Lewin, Williams & Saylor, Inc., Newark, N. J.

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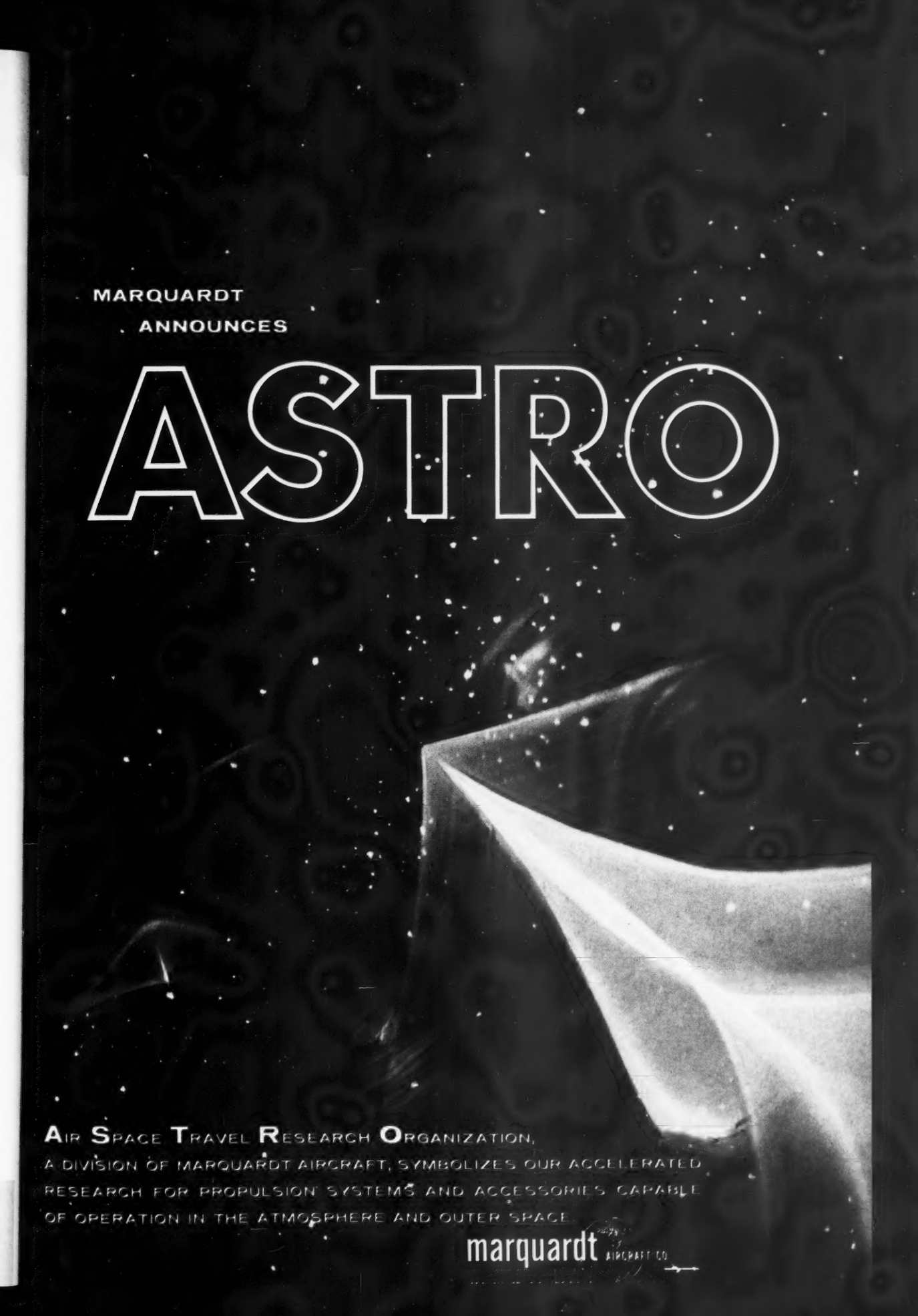
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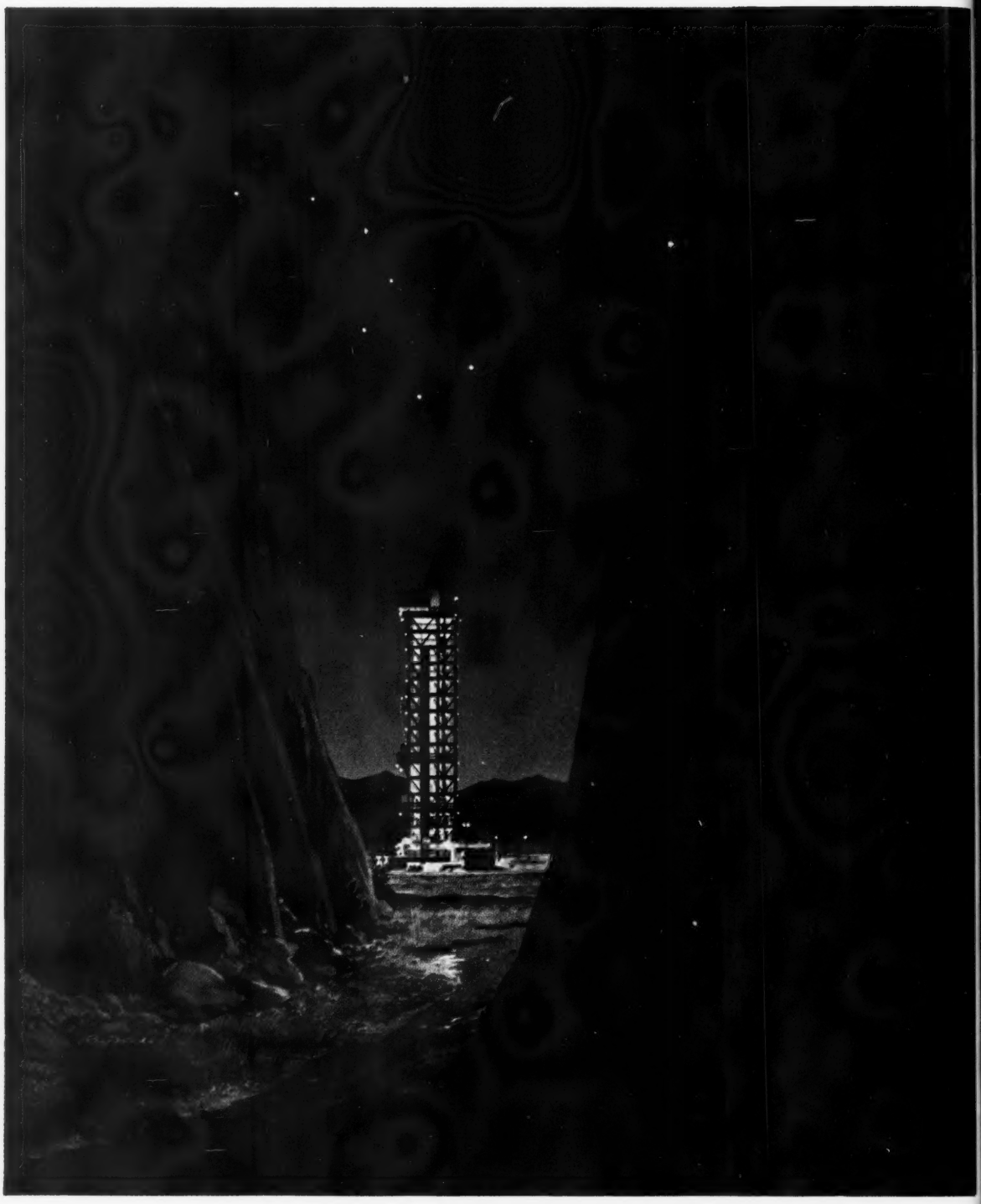

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